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Survey of Computational Trust and Reputation Models in Virtual Societies

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Abstract: The technical research in the field of computational mechanisms for trust and reputation in virtual societies is a latest discipline oriented to increase the reliability and overall performance of electronic communities**.**Research in the area of trust and reputation systems has put a lot of effort in developing various trust models. In open multi-agent systems trust and reputation is fundamental to improve cooperation by enabling agents to select good partners. In this paper we provide and discuss existing works on trust and reputation models based on centralized and decentralized approach in the area of Multi Agent virtual societies and highlight the limitations as well.Each model presents specific ideas related to calculation of trust. These different trust models are studied and thus subjected to comparison.Trust models play a vital role in determining how communications take place between various agents.

Keywords: Trust, Reputation, Centralized, Decentralized

I. INTRODUCTION

This paper provides an overview of trust research in computer science .We focus on relating how different trust and reputation models define and use trust in a variety of contexts. The paper begins with a general discussion and definitions of trust and reputation. Then the research survey has taken on various trust and reputation models according to the approaches used such as centralized and decentralized approach. A centralized architecture is based on a central agent on the other hand in a distributed architecture; the agents keep track of all the agents' behavior [1].*SPORAS* and *HISTOS* falls into the category of centralized models and the decentralized models discussed here are *Marsh*, *REGRET*, *FIRE* and *CREDIT* [3].These models vary from one another based on several standard components, such as the architecture in which they were built on, or in the methods used to evaluate trust score. The centralized approach is not deemed to be appropriate for a dynamic environment as the network node that houses the central data may not be accessible all the time [1].In centralized systems, instead of all agents keeping records of their exchanges, only single record for every agent exists. This model is more appropriate to environments with large numbers of agents decentralized approach is preferable for environments with smaller number of agents, where memory is not a consideration [2]. Examples of such models are Marsh and Regret [4].

II. DEFINING TRUST AND REPUTATION

A. *Trust*

Trust is a term that is broadly used in numerous contexts and generally concerned with security and privacy. Trust is a multi-dimensional entity which contains variety of attributes such as reliability, security, dependability, and integrity between others [1].Trust is a belief an agent has that the other individual will do what it says. It is a firm faith in the reality or potential of someone or something. "[Trust is] a subjective expectation an agent has about another's future behavior based on the history of their encounters" [5]

B. *Reputation*

Reputation is the method by which you are viewed by the group of people and your society and the way these people think of you. In other words it is defined as the general belief or judgement of the pubic concerning a person or thing [6].

1) Reputation building phase:

Reputation of an agent begins from low or neutral level. At this stage, not many trustier agents would like to interact with this agent. On the other hand, due to random examination by various trustier agents, this agent can get some requests. Slowly its reputation is elevated due to the positive feedbacks received from satisfied trustier agents.

2) Reputation damage phase:

At the time an agent builds up its reputation, it is known to an increasing number of trustier agents. Trustier agents start to call its services. Slowly, the workload of agent increases which eventually results in longer delays for several requests. Negative responses start to destroy agent's reputation.

III. TRUST AND REPUTATIONMODELS

Trustworthiness evaluation models utilize probabilistic, socio-cognitive, and organizational techniques to permit trustier agents to approximate the potential risk of interacting with a certain trustee agent. Once the trustworthiness evaluations for a set of candidate trustee agents have been fulfilled, trust-aware interface decision-making approaches help the trustier agent to choose a trustee agent for interaction at a particular point in time. However, prior to study trust models, we consider the different methods in which the models can be classified.

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A. Centralized model

In centralized systems there is a particular central server that is responsible for the actions of collecting trust score from every peer, performing calculations on the collected reputation value from all opinions and generates the results of its calculations open to anybody in the society [3]. In this context, trust score basically refers to opinions of individuals about the performance of others. Mostly this structural design is used by online communities such as eBay and Amazon.com. A centralized system is shown in Fig. 1.which contains middle authority known as a *reputation centre* which is updated by individuals when they give their judgment of one another as a rating, after each interface. After each update, the centre authority calculates new reputation values based on opinions stored from other parties. The reputation values are then given to all who has questioned the central system for reputation information.

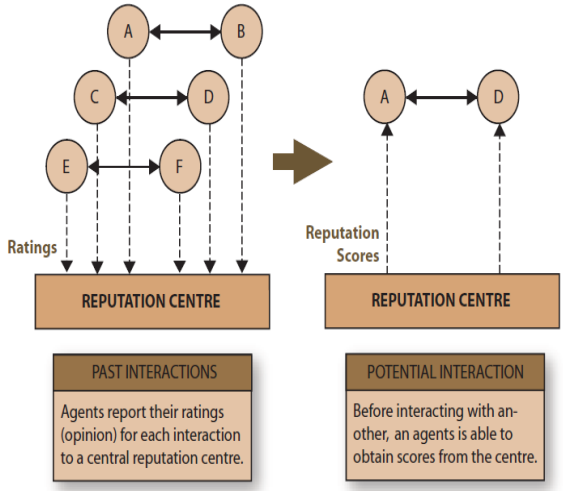

Fig. 1.A centralized trust system

1) *SPORAS:*

SPORAS was introduced to improve online reputation models [8]. In this model, when a newcomer enters the online community it starts with a *minimum reputation value* which is updated as a result of their activities in the entire system. An important property of an individual's reputation is that the reputation cannot fall to a point below that of a newcomer. So an individual never has an incentive to run off the system and re-enter under a new distinctiveness. In systems that allow reputation levels of an individual to drop below the level of a newcomer, there is a noticeable incentive to depart and re-enter the system. This type of behaviour permits an agent to fallaciously increase its reputation score. SPORAS define a minimum level of reputation ratings for newcomers, which are updated after each interaction [1].This feedback represents the reliability that the other parties place in the individual after the latest transaction. In SPORAS, each individual can only rate another individual just the once. So, when an individual has rated another more than once, the most recent rating is used. In SPORAS, the amount of an individual's reputation level is not only dependent on feedback, but also on the present reputation level. The individuals with very high reputation values experience much smaller ratings change after each update than individuals with a low reputation [4]. This property restricts the increase in an individual's reputation level to a high level swiftly. Finally, the ratings used to compute reputation are discounted with time, so that latest ratings have more weight. This is an easy and effective way to crack the problems related to trust and reputation, exhibited by the dynamic behaviour of individuals. By increasing the weight of more recent ratings the value of reputation obtained will be a more true illustration of an individual's current behaviour.

Limitations of SPORAS approach

SPORAS does not have a method by which an agent can attain reputation from the agents that it thinks more trustworthy. This *community knowledge* (knowing which agents are more reliable to provide true reputation information) is not taken into consideration when calculating trust from aggregated reputation values [3]. Secondly, SPORAS is a centralized approach so it is not suitable for applications in open MAS [7]. More particularly, the agents do not have a personal database of their individual ratings, since the central system is used to store the ratings and accessed when required. This is not a suitable approach in a dynamic situation, because the network nodule that houses the central data may be unapproachable from time to time. In such cases if an agent needs ratings from the database, it will not have a source of data for those ratings and the agent will be incapable to estimate an efficient level of reputation.

2) *HISTOS*:

HISTOS was later introduced as an improvement to SPORAS [9]Here a personalised reputation value for an entity is based on the principle that an agent has faith in friends more than strangers;hence it provides a simple solution to deal with unreliable opinions [3]. Moreover, in HISTOS, the pair wise ratings are represented as a directed graph in which the nodes are used to represent the users; the weighted edges represent the latest reputation value, and the direction of the edge points to the rated user. The agent owner of the graph is represented by root node. The reputation of an agent at level Z of a graph (with Z> 0) is calculated recursively as a weighted mean of the rating values that agents in level Z -1 gave to that agent. The weights are the reputations of the agents that rate the target agent. The agents who have been rated directly by the agent owner of have a reputation value equivalent to the rating value. The model also limits the length and number of paths that are used in calculation. The reputation value does not depend on the context and no particular mechanisms are provided to treat with cheaters [4].

Limitations of HISTOS approach

One of the important limitations to the HISTOS approach is that the graph data is held centrally, and the lack of the authority that provides this information may have a disastrous result [3]. If the graph data was circulated or replicated across a network, then there would be additional

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problems in maintaining the information so that it was consistent and accurate across all the network nodes that housed it.

3) *eBay*:
EBay (eBay WWW 2007) [10]: eBay has built a feedback Reputation method for its Customer-to-Customer websites. The purpose of designing this system is to shift the trust and reputation mechanism in the real life human market to the internet-based e-Market.These models contains information regarding an agent's past behaviors. This information is helpful to figure out the trustworthiness of that agent in terms of its capability and consistency. Online reputation mechanisms (e.g. those on eBay [10] and Amazon Auctions) [11] are the most broadly used such models.

They are based on centralized rating system so that their users can report about the performance of one another in past communication through rating and leaving textual comments [7]. By this, groups of users can learn about the past activities of a given user to make a decision whether it is reliable to do dealing with. For example an eBay user, after an interface, can rate its associate on the scale of −1, 0, or +1, which means positive, neutral and negative score respectively.

The scores are stored centrally and the reputation value is calculated as the sum of those rating scores after six months. Therefore, a user's overall trustworthiness in these models is represented by a global single value called as reputation

Limitations of eBay
In eBay the ratings are aggregated equally, so the method cannot adapt well to changes in a user's performance (e.g. a user can cheat in a small number of exchanges after obtaining an elevated reputation value, but still retains a positive reputation). In these systems, the reputation values hold very less information and users of these systems always need to look for textual comments to gain more information. Therefore, such mechanisms are not appropriate to computational agents, which must generally build decisions separately. In addition, as there is no central authority that can supervise all the agents in open MAS, an agent may well inquire the reliability of those centralized reputation models and decides not to use them [7].

B. Decentralized models
In contrast to the centralised systems, decentralized systems have no central authority. The central reputation system is replaced by many smaller distributed ones. In other words, each node accounts only its own communication record [3]. In these systems, information is thus collected from one or more scattered stores, or directly from numerous individuals, as shown in Figure 2. The major difficulty with the distributed approach is that each time trustier wishes to assess a trustee, the trustier must discover and gather data from several sources of reputation in the community and combine it.

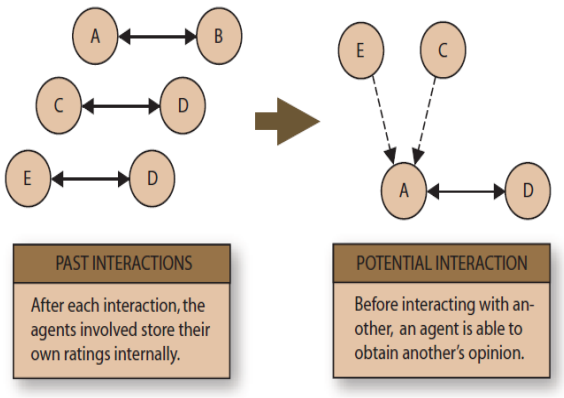

Fig. 2. A decentralized trust system

1) *Marsh:*
Marsh (1994)was one of the first to reflect on the concept of trust from a computational point of view and his model is the first renowned computational model of trust.Marsh considered that knowledge, utility, importance, risk, and apparent competence are important aspects associated to trust [3].It was modeled in three dimensions: basic, general and situational trust[12].

- Basic Trust– Basic trust is concerned with good experiences which lead to a greater level of trust.
- General Trust–General trust is the trust an agent has in another without taking into account any particular situation.
- Situational Trust– situational trust is the amount of trust an agent has in another, considering a particular state.

The concept of trust management provided by Marsh does not treat the collection of opinions provided by other agents; he only takes into account direct trust among two agents [5]. The phase of risk is dealt with explicitly based on costs and profit of the considered engagement. The decision making process is threshold based. Among additional parameters the cooperation threshold depends on the perceived risk and capability of the potential interaction partner. If the situational trust is more than the value calculated for the cooperation threshold, cooperation will eventually take place otherwise not.

In addition, the decision making can be extended by the idea of reciprocity, i.e. if one does another one a kindness, it is estimated to recompense at some time.An important property of Marsh's model is that it incorporates and promotes reciprocation, toe certain level. Hence, collaboration between agents helps raise their trust in each other, whereas defection reduces the trust.

Limitations of Marsh
Marsh does not provide methods by which trust information about a particular agent can be gathered from a community of agents [3]. Thus it can be said that his model does not support the spread and collection of reputation information. We believe reputation information is necessary in order to make an accurate trust evaluation

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if one does not have individual familiarity of interacting with other agents.

2) *REGRET:*

Sabater and Sierra (2001) propose REGRET as a reputation based model for sociable societies. These societies consist of agents that form group with others of the same category and like the companionship of others. REGRET considers trust as a multi-facet concept and a combination of pieces of information [5]. In REGRET, reputation is a combined result of individual dimension, social dimension, and ontological dimension. Firstly, experience achieved by direct interactions with an individual in the society forms the *individual dimension.* Secondly, the experience gained by communicating with the society to which the individual belongs forms the *social dimension.* Subjectivity in the reputation created by an agent about another is a consequence of the fact that each agent has its personal ontological structure, which identifies the significance (weighting) of all the different types of reputation. The reputation model is divided into three specific types of reputation depending on the information source that is used to estimate them [4]:

- *Witness reputation*: If the reputation is computed from the information coming from witness.
- *Neighborhood reputation*: If the reputation is calculated using the information extracted from the social dealings among associates.
- *System reputation*: If the reputation value is based on roles and general properties.

All the modules work jointly to present a complete trust model based on direct knowledge and reputation. However, the modular approach in the design of the system allows the agent to make a choice that which part it desire to use. In the case of this work, REGRET can be seen to fruitfully deal with lots of issues of trust and reputation in virtual societies and its strength lie in the compositional definition of reputation that it uses as a foundation for the model.

Limitations of REGRET

However, this approach fails to concentrate on the issue of strategic lying due to the assumption that there is an unselfish society. In addition, the model is highly prone to noise as a result of the way in which the impressions are weighted and summed [3].

3) *FIRE:*

The REGRET model elaborated the concept of reputation as a compositional value. It recognized three proportions of reputation: ontological, social and individual. The greatest strength of this approach is that in the absence of individual familiarity an agent can attain information from witnesses in the community. In case any absence of witnesses in the society, an agent can analyse a trust using the role-based affairs that exist between agents. On the other hand this approach reaches its limitation when the supposition of the accessibility of role information is removed. This limitation is addressed by Huynh et al. in the FIRE model (Huynh et al. (2006) and Huynh (2006)) [3] that incorporates interaction trust, role based trust and witness reputation. Along with these different types of trust (collected from different sources of information) this model defines *certified reputation* as an additional source of trust information and an answer to the above drawback. Here, each type of trust information is processed by a particular module of FIRE: interaction trust (IT), witness reputation (WR), role-based trust (RT), and certified reputation (CR) components [7]. FIRE integrates all four sources of information and is able to provide trust metrics in a wide variety of situations. [5].Moreover, certified reputation is created via ratings that an agent provides by it. For example, suppose agent X is trying to estimate the reliability of agent Y. When there is no information that can use in its trust computation, it asks Y to provide ratings from its earlier experiences. In reply, Y provides X with a set of proficient ratings, which it has collected from asking others to estimate its performance at the end of an interface. This means that X can ask Y to supply it with ratings of Y's past exchanges without having to look for a huge social network or ask other agents that have interacted with B in the past. The ratings provided by Y are certified by the agents that gave that specific evaluation of B's performance. It is assumed by the model that a security mechanism is present in it that prevents agents from tampering with these certified ratings.

Limitations of FIRE

In the context of our effort, FIRE addresses some of the limitations with searching social networks for agents that can supply reputation information about a particular agent and with identifying which agents have interacted with the agent for whom a trust score is being calculated. However the certified reputation has to be considered with a little doubt, since agents giving the unrefined information to others for the computation of their own reliability [3]. Therefore, there are great chances for an agent to provide false information to develop its trustworthiness, and in open dynamic systems an agent has to be capable to deal with this fake information.

4) *CREDIT:*

Ram churn (2004) [3] presents a model, called CREDIT, of trust that is different from REGRET and FIRE in the way in which it comes at a trust level for a particular agent. Particularly, CREDIT equips an agent with the capability to assess the loyalty of an agent using two types of facts (alike to those found in REGRET and FIRE): using direct exchanges and using reputation. However, CREDIT differs in the method used to transform the verification to a trust value, and how this trust value is used afterwards. Particularly, the CREDIT model uses fuzzy sets to model trust levels that are used by agents to assess their associates with respect to arranged contracts. In addition, this model incorporates the aspect that agents exist in electronic institutions, so, the agents' relationships are governed by the norms and conventions of that institution (Ram churn et al., 2004b). This result in a key

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attribute, which no other trust models offer: distinguishing between the performance of the agent and the environment in which the agent is located. The bulk of models take the position that from the standpoint of the agent that is calculating a trust value for a communication partner, it does not matter if the interactions with that partner fail duet the partner's behaviour or due to the environment from which it is operating. However, the CREDIT model offers a good solution to this problem.

Here, the agent can differentiate the source failure by investigate the norms and rules that define the situation, and rules that direct the behaviour of agents. For example, if an agent is running from a defective network, then CREDIT is intelligent to distinguish among the agent's performance and the faulty network by examining the norms that define that environment.

CONCLUSION

We report the different methods of trust calculation based on Reputations, policies and implemented using centralized and decentralized approach. In this paper we reviewed the various trust and reputation models along with their limitations and differences among them. We have concluded that CREDIT model offers a best solution in situations where interactions with any partner fail due to its behavior or due to the environment in which it operates. CREDIT is intelligent enough to differentiate performance of an agent and the faulty network.

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