Trust Management for Composite Services in Distributed Multi-agent Systems with Indirect Ratings

(Extended Abstract)

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1. INTRODUCTION

So far, trust evaluation models depend highly on collected evidences, which are mainly in the form of ratings, to produce trust values [3]. However, many situations require agents to form groups to provide more complicated services (composite services); meanwhile, consumers rate the quality of a composite service as a whole rather than individual group members [2]. Namely, all providers, who are in charge of the sub-services, are not rated individually. The lack of effective rating distribution mechanism has produced a gap in trust management systems since it causes the missing evidence of the members joined in composite services; thus, it can affect the robustness of trust evaluation models.

To distribute a group rating is a non-trivial problem, especially when the given ratings could damage agents' reputation. The subjective and indivisible nature of ratings restricts the use of fair-division [1] approaches in finding a solution. Under uncertainty assumption of members' contribution and group structures, self-interest members could argue that they performed well and lay the blame on others for any undesirable rating of the group. To distribute group rating while reducing the conflict of interest of members, this paper proposes an evidence-based approach, considers supporting facts related to the performance of members to distribute the group rating. Firstly, we develop a communication protocol to cope with collecting evidence in distributed environment. We form the performance graph from the social relations of members and then distribute group ratings based on obtained graph characteristics.

2. THE EVIDENCE-BASED APPROACH

Under uncertainty, the distributed ratings of members are influenced by its base performance (the performance of agent when ignoring the current environmental factors, denoted as $QoS_{base}(p_i)$) adjusted by the uncertainty factor (Δ_u) of the current group:

$$QoS(p_i) = QoS_{base}(p_i) + \Delta_u\,(p_i \mid G) \tag{1}$$

To find the base performance of each agent, this paper introduces an extended evidence space, which includes current group G as an evidence to historical transactions provided by all members of group G. This approach can assure the space always has at least one evidence. Each group member will then form a performance graph, which comprises a set V of nodes (representing providers) together with a set of undirected weighted edges, i.e., E, indicating the degree of the performance relationship between two nodes. Edges contain two coefficients: distance and pairwise performance. The distance of two nodes is calculated by using:

$$d_{p_i p_j} = \frac{1}{1 + \log(k)} \tag{2}$$

, where k is the number of evidence that contain both p_i and p_j; $d_{p_i p_j}$ has value in (0, 1]. Smaller distance means two agents work together more frequently. The pairwise performance of the agent p_i and agent p_j is calculated using

$$r_{p_i p_j} = \frac{\sum_{l=1}^{n} r_{\{G_n \mid G_n \in H_i\}}.\delta_l}{\sum_{l=1}^{n} \delta_l} \tag{3}$$

, where δ_l is the discount factor that control the weight of evidence based on timestamp. The evidential performance of the p_i in G is calculated from all provided evidence containing p_i. With the presence of other members in group G, the evidential performance of p_i is:

$$ep(p_i|G) = \frac{\sum_{j=1}^{j=n} d_{p_i p_j}^{-1} r_{p_i p_j}}{\sum_{j=1}^{j=n} d_{p_i p_j}^{-1}} \tag{4}$$

, where $ep(p_i|G)$ can be considered as the base performance of in the environment of group G. Next, the uncertainty can give a member a rating reward or punishment based on the evidence relevancy, which is the similarity of common features in feature set f_G between two groups:

$$Sim(G_i, G_j) = \frac{|f_{G_i} \cap f_{G_j}|}{|f_{G_i} \cup f_{G_j}|} \tag{5}$$

, where $0 \leq Sim_i(f_{G_i}, f_{G_j}) \leq 1$. The unaccountability of the extended evidence of p_i and the current group G:

$$UA(p_i|G) = 1 - \frac{\sum_{j=1}^{k} Sim(G, G_{ij})}{k} \tag{6}$$

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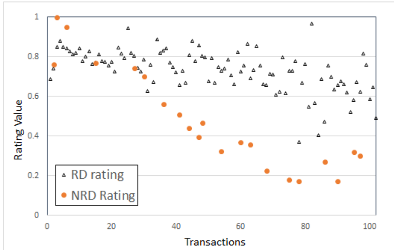
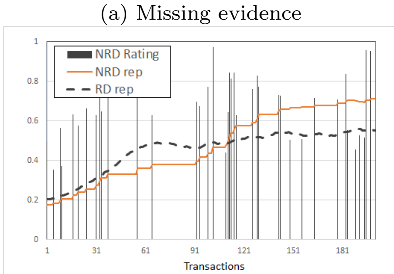
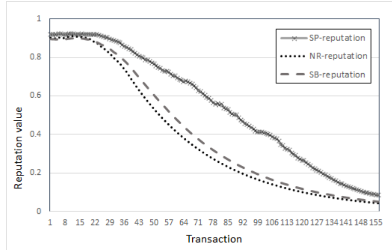


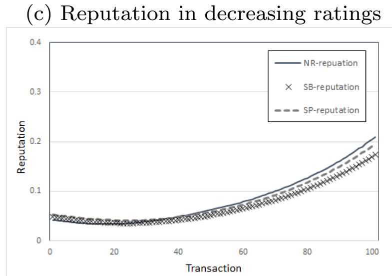
(a) Missing evidence



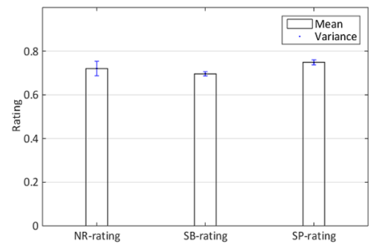
(b) Impact of missing evidence



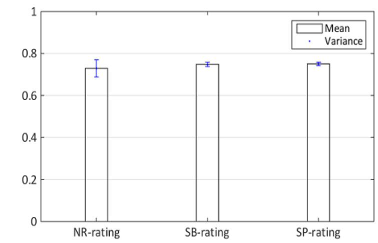
(c) Reputation in decreasing ratings



(d) Reputation in decreasing ratings



(e) Same service composition



(f) Same member composition

Figure 1: Some experimental results of rating distribution in different settings

, where G_{ij} is group containing p_i. In case that member p_j has no historic transaction, the extended evidence space makes $UA(p_i|G) = 0$. Apply Equation 4 and 6 to Equation 1, the rating distribution for each p_i in a group:

$$R(p_i|G) = \begin{cases} ep_{p_i} + (1 - UA(p_i|G)) \cdot (r_G - ep_{p_i}) & \text{if } ep_i \le r_G \\ ep_{p_i} + UA(p_i|G) \cdot (r_G - ep_{p_i}) & \text{if } ep_i > r_G \end{cases}$$

Some properties of the distribution (without proof): (1) Members with no evidence (or new comers) receive the same rating as group rating; (2) Members with smaller unaccountability receive less reward or punishment, and likewise.

3. EXPERIMENTAL RESULTS

Several experiments have been conducted to evaluate the consistency of reputation system and the satisfaction of members over distributed ratings. We consider that agents are honest and there is no collusion to manipulate the evidence. Providers were created with various performance profiles and a provider can join only one group at a time. The comparison of two systems, one with (RD) and one without a rating distribution method (NRD), shows that NRD system suffers from the missing evidence problem when the number of composite services increases (Fig.1a). Consequently, the NRD system is less reliable than RD since NRD calculates reputation values based on incomplete evidence (see Fig.1b).

The satisfaction is analysed by comparing our distribution (SP method) with two other methods, namely, service similarity based (SB method [2]) and a naive distribution (NR), which gives the same group rating to all members. Fig.1c and Fig.1d show the reputation under decreasing and increasing group ratings respectively. Both SB and SP methods show additional adjustments for ratings compared to NR method because the unaccountability factor makes reputation resist to sudden changes of group rating to evidential performance. As a consequence, the reputation of NR and SB changed relatively fast compared to SP method. Obviously, the rated members have better satisfaction under receiving low group ratings. In another experiment with more randomised ratings, the SP method outperformed the others two since it can keep the reputation of provider relatively high and stable. Finally, we investigated the effect of service composition to distribution in two cases. First, when providers join a group with same service composition (members can be different), statistical results show that the SB method has smallest rating variation amongst the three (see Fig.1e). It is because SB approach considers only the service similarity while ignoring the difference in members composition. However, in the case of groups with same member composition, SP approach has the least variation in both rating and reputation (see Fig.1f). These results also indicate that SP method can give better reputation protection for providers who frequently work together. They are less likely to receive unexpected ratings than other methods because the accountability factor is smaller than other.

4. CONCLUSIONS

This paper has investigated the indirect ratings in the context of groups and proposed an efficient method to distribute group rating to its members while diminishing the conflict of interest. The approach can be integrated easily into any reputation system to enhance the consistency and accuracy by adding performance evidence for trust evaluation.

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