Trust-Aware Cooperation

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Abstract

In mobile teamwork environments two basic problems exist: how to discover someone based on a profile (skills, reputations) and how to assess that person's "credibility" (trust). A lot of work has been done on the issues of collecting and spreading reputations and subsequent computation of trust. The application of such data for decision making, however, is still missing. In this paper we present a solution for scheduling exchanges among participants of an online community which take into account their trustworthiness.
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1. Introduction - Reputation and Trust

Rapid growth of the Internet has made it possible for any computer around the globe to participate in a collaborative (e-commerce, teamwork, etc.) scenario. Frequently, parties working together know nothing about the "quality" of their communication partners (e.g., how much they can trust them). In the following discussion we focus on the issue of trust as one concrete quality in such scenarios. If "strangers" are to collaborate reputation reporting and trust assessment mechanisms play a crucial role for proper functioning of those collaborations ([1]).

Numerous works on reputations and trust management in online communities have appeared recently. In our opinion, an inter-disciplinary approach taking into account works on the trust issues from the areas of sociology, psychology, and economics is needed here. Figure 1 shows the common reference model that most approaches apply. The reputation management module collects information about the past behavior of the members of the community under consideration as well as makes this information available for others to use. Once the data about past interactions of potential partners has been collected, the trust management module comes into play and calculates predictions of their future behavior. Finally, the decision making module, analysing the performance of those predictions in the interaction that is about to happen and having the risk averseness related inputs from the user, makes the decision whether to interact or not. The results of the interactions are then fed back into the reputation management module for the future use.

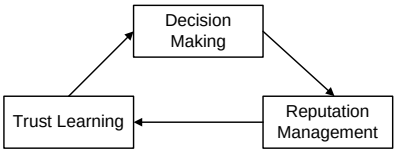

Figure 1. Reputation and trust management reference model

At the moment research focuses on how to organize reputation reporting and, subsequently, compute the trustworthiness of potential partners. But, the question how to use trust data to select optimal strategies in interactions is not addressed. In a typical example of exchanges of goods for money, a seller may require an insufficiently trustworthy buyer to deliver the payment before the delivery of the goods. On the other hand, this may be unacceptable to the buyer because of the seller's bad reputation and the buyer may as well require the seller to deliver the goods before the money is delivered. In most cases the reputation records of the two partners will suggest, however, that it is not necessary to go into these two extremes and that the deliveries of the goods and the payments can be arranged in such a way that the partners' expectations are met with high probability. For this purpose a closer analysis of the quality of the exchange strategies with respect to the trustworthiness of the partners is needed. This is where our approach comes into play. It represents a trust-related decision making scheme that can be used in many collaboration scenarios.

2. The Setting - Safe Exchange

[4] presents the basis for our work. We consider exchanges between two participants in an e-commerce sce-

nario. We assume that one of the two participants (the "supplier") is selling a set of "goods" to the other partner (the "consumer"). We further assume that they agreed about the overall price the consumer will have to pay for the goods (P) as well as that the consumer may deliver the payments in arbitrarily sized chunks. The set of goods consists of a number of items and it is assumed that the supplier's value function $V_s(x)$, describing the supplier's cost for generating and delivering any item x of the goods, as well as the consumer's value function $V_c(x)$, describing what the good x is worth to the consumer are both known to both partners.

The problem can be now stated as follows: how to combine the deliveries of the goods and the payments in a way such that, at any point during the exchange, future gains of both partners are greater than their gains from instant defection. With such an exchange strategy the partners have no rational incentive to break the exchange at any point before its end. Therefore, an exchange sequence that meets these conditions is called *safe* (exchange) sequence.

[4] defines general conditions for the existence of a safe exchange sequence. They are expressed as requirement that states that the current utilities of the two partners lie between two bounds, P^{min} and P^{max}, that are functions of $V_s(x)$, $V_c(x)$ and P. It is shown that in isolated exchanges a safe sequence cannot exist whereby reputation effects are suggested as a mechanism that may enable the existence of a safe exchange. In this case a quadratic time algorithm that finds a safe sequence, if one exists, is provided.

3. Trust Aware Safe Exchange

The results described in the previous section can be applied in many different settings. The necessary condition for the applicability of the approach is that the good being sold is divisible into a set of chunks whereby the valuations of these chunks are known to the both partners. This condition can be met in many practical situations such as trades in eBay's auctions, exchanges of MP3 files for money in a P2P system or trades of services in a teamwork environment. But, a serious practical problem associated with the original approach is that a fully safe exchange sequence for the deliveries of the chunks of goods and the payments may not exist in many cases. Assuming that interactions in the mentioned systems are backed by underlying reputation and trust management models, a trust aware extension of the above results is required as it may help schedule exchanges between (sufficiently) honest partners in these cases.

Every set of goods that the supplier wants to sell to the consumer and their valuations, $V_s(x)$ and $V_c(x)$, have associated gains for the two partners. If the exchange can be carried out in the safe manner these gains are guaranteed, but, in situations when a fully safe exchange sequence does not exist (due to the mentioned valuations) these gains cannot be achieved. Yet, if their opponents are sufficiently trustworthy, the partners can accept even unsafe exchanges. But in this case an adaptation of the original approach that takes into account the expectations of the two partners is needed. Therefore, we proceed in the following way: We assume that the two parties can compute probabilistic estimates of a specific (in the simplest case honest and dishonest) behavior of the other side. This is the task of the underlying trust computation module. [3] presents a theoretically well-founded solution for this problem. [2] is a practical approach that can be used in P2P environments. Now, we expect the partners to refine their expectations from the exchange by decreasing the expected gains. The question of how much to decrease the expected gains is left to the partners themselves. Obviously, these decreases will be based on the risk averseness of the two parties and the trustworthiness of the other side. Without elaborating further on that, note that these expectations easily translate into two bounds representing the values that the partners accept to be indebted. Finally, having these new, decreased, expected gains we provide a provably correct quadratic-time algorithm that finds an exchange sequence, if one exists, that satisfies these expectations.

4. Conclusions

In this paper we propose a trust-aware mechanism for scheduling exchanges of goods for money. It is based on the risk averseness related inputs from the two exchange partners. The main contribution of the work is that it provides the theoretical foundations that enables sufficiently trustworthy partners carry out exchanges in cases when they cannot proceed in a completely safe manner. Future work will consider a game-theoretic extension of this work arising when the partners are interested in maximizing their gains from the exchanges.

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