Formalising Trust for Online Communities

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ABSTRACT

Provision of services within a virtual framework for resource sharing across institutional boundaries has become an active research area. Many such services encode access to computational and data resources. Consequently, we envision a service rich environment in the future, where service consumers are represented by intelligent agents. If interaction between agents is automated, it is necessary for these agents to be able to automatically choose between a set of equivalent (or similar) services. In such a scenario trust serves as a benchmark to differentiate between services. The concept of trust suffers from an imperfect understanding, a plethora of definitions, and informal use in the literature. We present a formalism for describing trust within multi-institutional service sharing that can be embedded in an artificial agent; enabling the agent to make trust-based decision.

Categories and Subject Descriptors

C.4 [**Computer Systems Organization**]: Performance of Systems—*Reliability, availability, and serviceability*

General Terms

Algorithm, Security, Measurement

Keywords

Trust, Reputation

1. INTRODUCTION

The pervasiveness of online services facilitates a novel form of communication between individuals and institutions, thus supporting new flexible work patterns and making institutional's boundaries more permeable. Upcoming standards for the description and advertisement of, as well as the interaction with and the collaboration between, online services promise a seamless integration of business processes, applications, and online services over the Internet. As a consequence of the rapid growth of online services, the issue of trust becomes central for businesses. There are no accepted techniques or tools for specification and reasoning about trust. There is a need for a high-level, abstract way of specifying and managing trust, which can be easily integrated into applications and used on any platform. A typical application requiring a formal trust decision becomes apparent when service consumers are faced with the inevitability of selecting the"right" service. The distributed nature of these services across multiple domains and organisations, not all of which may be trusted to the same extent, makes the decision of selecting the "right" service a demanding concern especially if the selection proves is to be automated and performed by an intelligent agent. This paper presents a formalised approach to manage trust in online communities.

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2. THE TRUST FORMALISM

In this paper, we enunciate trust as an assumption or an expectation we make about others in the world. This expectation is based upon more specific beliefs which form the basis or the components of trust [2]. These beliefs are the beliefs we have for someone we want to trust; the basic components of the mental state of trust. Those beliefs are the answer for the question when we ask ourself "What do we have in mind when we trust a service?". For example, we may trust a service because we *believe* that service is able to do what we need (competence) and it will actually do it quickly (promptness). Many types of beliefs exist. We classify them into:

1. **Non-situational Beliefs:** These beliefs concern the trustee and they are not related to the current situation. Institutional beliefs include:
   - Competence Belief: The service's raw ability to accomplish a task, such as providing accurate results or performing a desired action [2].
   - Availability Belief: The availability of the service.
   - Promptness Belief: The speed at which the service responds to task requests by accomplishing the agreed upon task.
   - Cost Belief: Cost refers to the monetary value that the user is willing to pay.
2. **Situational beliefs:** These beliefs concern the situation of the truster and the benefit that he will get from the trusting decision. Situational beliefs include:

- Harmfulness Belief: These beliefs concern the risks of propagating data mining task to a Web service.
- Importance Belief: These beliefs concern the user-centred judgment of the importance of the task. The greater the importance is, the greater the likelihood to trust.
- Utility Belief: Utility refers to the benefits that the user will gain from the concerning task.

Beliefs can be acquired from two sources: our direct experience or as an acceptance of what other people tell us.

1. **Direct Experience** means trying things out in practice, observing things and generally getting a lot broader range of evidence before committing to a belief. Unfortunately we only have time to try a limited number of things.

2. **Recommendations** are the traditional source of information. It is a form of advice from someone we know such as colleague, friend, credit organisation, etc

2.1 Combining belief values from various Sources

The value of a belief should reflect the accumulation of all values produced by various sources with respect to the uncertainty nature of sources. In this paper, we use a weighted Dempster-Shafer theory to combine beliefs from various sources. See [3] for standard Dempster-Shafer theory. The fundamental DST combination rule implies that we trust any sources S_i and S_j equally. However, these sources are not always reliable and we usually trust some sources more than others, for instance an agent might trust the belief values from its own experience more than the belief values from the recommendations. This sort of deferential trust can be accounted for by a simple modification to the DST formula, in which the observations m_i are weighted by trust factors w_i derived from the corresponding expectations, histories of the corresponding source S_i's performance, etc. The weighting process has already been investigated by Basak et al. [1]. Their proposed formula of weighted DST is defined as follows:

$$m_1 \triangle m_2 = m_1 \cap m_2$$

,where $\triangle$ denotes the combination with usual Dempster's rule and

$$m_i = \frac{m_i^{wi}(A)}{\sum_{B \subseteq \theta} m_i^{wi}(B)}$$

2.2 Trust Adaptation: Dynamic Weighting

When the ground truth is available, e.g. shortly after current measurements or from additional information channels, it can be used by making the weight factors w_i as functions of time . We believe that adding dynamic weighting to the Dempster-Shafer framework is one of the major contribution of our work. A simple but effective practical implementation is to define

$$w_i = \sum_{n=0}^{\infty} c_i(n).\frac{1}{n}$$

,where $c_i(n)$ is the function describing the correctness of the source S_i's estimation at the time n:

$$c_i(n) = \begin{cases} 0 & \text{correct estimation} \\ 1 & \text{incorrect estimation} \end{cases}$$

and the $\frac{1}{n}$ is the "penalty factor", which is used to control the changes of the weight value.

2.3 Trust Computation and Selection

The weighted Dempster-Shafer theory is used to compute the aggregated values for a belief from different independent sources. The next step is to aggregate the beliefs in a single "trust value". Each belief influences the trust value is associated with an influence factor k. The k's value for a belief indicates how the belief influences the trust decision. The value of k is either positive or negative in the range [-1..1], such that:

$$w : \begin{cases} > 0 & \text{when the belief promotes the trust value} \\ < 0 & \text{when the belief inhabits the trust value} \end{cases}$$

For example, the k for the promptness belief might be assigned a positive value as it promotes the trust value, whereas the k for the harmfulness belief might be assigned a negative value as it inhabits the trust value. The trust value is computed as the sum of all the influencing beliefs

$$trustvalue = \sum_{i=0}^{n} k_i * belief_i$$

,where n is the number of the influencing beliefs, k_i is the weight of the $belief_i$.

3. CONCLUSION AND FUTURE WORK

The rapid growth of online services indicates that online communities should be able to make a trust-based decision to select the "right" service. In this paper, we introduced a formalism for trust that can be embedded in an intelligent agent: enabling it to make a trust-based decision. We started investigating the trust's components and showed how those components are aggregated to form a trust decision. The trust components in our finding were mere beliefs. Therefore, we applied a belief function, weighted dempster-shafer theory to aggregate these beliefs. We also introduced an adaptation trust approach by dynamically changing the weight of the sources based on their historical performance. In a future work, we aim to consider composite services in a workflow and look on how the formalism could be applied.

4. REFERENCES

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