Quality of Trust for Social Trust Path Selection in Complex Social Networks

(Extended Abstract)

Guanfeng Liu
Department of Computing
Macquarie University
NSW 2109, Australia
gliu@comp.mq.edu.au

Yan Wang
Department of Computing
Macquarie University
NSW 2109, Australia
yanwang@comp.mq.edu.au

Mehmet A. Orgun
Department of Computing
Macquarie University
NSW 2109, Australia
mehmet@comp.mq.edu.au

ABSTRACT

In online social networks, there are usually many social trust paths between agents. Thus, a challenging problem is which social trust path is the optimal one that can yield the most trustworthy evaluation result. In this paper, we present a new complex social network structure and propose a new concept, Quality of Trust (QoT), for social trust path selection in complex social networks.

Categories and Subject Descriptors

J.4 [**Computer Applications**]: Social and Behavioral Sciences-*sociology*

General Terms

Algorithms, Experimentation, Human Factor

Keywords

Agent societies, Social networks, Agent trust

1. INTRODUCTION

In social networks, if agent A and agent B are adjacent (i.e., there is a direct link between A and B), A can give a trust value to B based on their interactions. Thus, if a path links two nonadjacent agents, the source agent can evaluate the trustworthiness of the target agent based on the trust information between the agents along the path. This process is called *trust propagation* and the path with trust information linking the source agent and the target agent is called a *social trust path* [2]. However, in a large-scale social network, there may be over tens of thousands of social trust paths between a source agent and the target agent, and each path can yield a trust value. A problem is that among multiple paths, which one is the optimal yielding the most trustworthy result of trust propagation.

In this paper, we first present the structure of complex social networks taking *social relationships* between adjacent agents (e.g., the relationship between a buyer and a seller) and *recommendation roles* of an agent (e.g., a supervisor as a referee in a job application) into account. These factors have significant influence on trust propagation [1, 5], but they are not considered in existing trust propagation and social trust path selection methods. In addition, we propose a new concept, *Quality of Trust* (QoT) taking the above three factors as the attributes to illustrate the capability of a social trust path to guarantee a certain level of trustworthiness in trust propagation. We also propose a utility function that takes these QoT attributes as arguments and can be applied to social trust path selection in complex social networks.

Cite as: Quality of Trust for Social Trust Path Selection in Complex Social Networks (Extended Abstract), Guanfeng Liu, Yan Wang and Mehmet A. Orgun, *Proc. of 9th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2010)*, van der Hoek, Kaminka, Lespérance, Luck and Sen (eds.), May, 10–14, 2010, Toronto, Canada, pp. 1575-1576.

2. COMPLEX SOCIAL NETWORKS

The complex social network structure [3] comprises the attributes of several impact factors, which influence the trustworthiness of trust propagation and hence the decision making of source agents.

2.1 Trust between Agents

In the literature, many different definitions of trust have been proposed addressing different aspects. In the context of this paper, trust between agents is defined as follows.

***Definition** 1. Trust* is the belief of one agent in another, based on their interactions, in the extent to which the future action to be performed by the latter will lead to an expected outcome.

Let $T_{AB} \in [0, 1]$ denote the trust value that agent A assigns to agent B. If $T_{AB} = 0$, it indicates that A completely distrusts B while $T_{AB} = 1$ indicates A completely believes B's future action can lead to the expected outcome.

2.2 Social Intimacy Degree

An agent can give more trustworthiness to the agents who have intimate social relationships with it than those with which it has less intimate social relationships [5]. Therefore, the *Social Intimacy Degree* (SID) should be defined to describe the extent to which two agents have intimate social relations.

***Definition** 2.* $r_{AB} \in [0, 1]$ is the *Social Intimacy Degree* between agent A and agent B in online social networks. $r_{AB} = 0$ indicates that A and B have no social relationship while $r_{AB} = 1$ indicates they have the most intimate social relationship.

The SID values can be obtained by using data mining techniques. For example, in [4], through mining the subjects and contents of emails in *Enron* Corporation, the relationship between two agents can be discovered and the corresponding SID value can be calculated.

2.3 Role Impact Factor

Rich activities of agents in social networks can be categorized into different domains (e.g., recruitment or product introduction) based on their characteristics. In a certain domain, recommendations from a domain expert are more credible than that from a beginner. For example, the recommendation from a *professor* to a textbook is more credible than that from a *student* in a subject taught by the professor. Therefore, the *Role Impact Factor* (RIF) should be defined to reflect the impact of an agent's recommendation role (e.g., expert or beginner) on trust propagation.

***Definition** 3. $\rho_A \in [0,1]$ is the *Role Impact Factor*, illustrating the impact of agent A's recommendation role on trust propagation. $\rho_A = 1$ indicates that A is a domain expert while $\rho_A = 0$ indicates that A has no knowledge in the domain.*

The RIF values can also be obtained by using data mining techniques in some particular applications [4].

3. SOCIAL TRUST PATH SELECTION

In this section, we propose a novel social trust path selection model with end-to-end *Quality of Trust* (QoT) constraints.

3.1 Quality of Trust (QoT)

We first propose a new concept, *Quality of Trust* (QoT) as follows.

***Definition** 4. Quality of Trust* (QoT) is the ability to guarantee a certain level of trustworthiness in trust propagation along a social trust path, taking trust (T), social intimacy degree (r) and recommendation role (ρ) as attributes.

In our model, a source agent can set multiple end-to-end constraints for QoT attributes (i.e., T, r and ρ) as the requirements of trust propagation in a social trust path. For example, source agent A can set the end-to-end QoT constraints for the social trust paths from A to M as $Q_{AM} = \{Q^T_{AM} > 0.5,\ Q^r_{AM} > 0.05,\ Q^\rho_{AM} > 0.5\}$ in the domain of *employment* or $Q_{AM} = \{Q^T_{AM} > 0.3,\ Q^r_{AM} > 0.4,\ Q^\rho_{AM} > 0.2\}$ in the domain of *product introduction*. Q^T_{AM}, Q^r_{AM} and Q^ρ_{AM} are the QoT constraints of T, r and ρ respectively.

3.2 QoT Attribute Aggregation

When specifying end-to-end QoT constraints of social trust path selection, we need to know the aggregated value of each QoT attribute in a social trust path.

3.2.1 Trust Aggregation

The trust values between a source agent and the target agent in a social path can be aggregated based on the strategy proposed in [6], where if there are n agents $a_1, ..., a_n$ in order in a social trust path (denoted as $p(a_1, ..., a_n)$), the aggregated trust value is calculated as in Eq (1).

$$T_{p(a_1,...,a_n)} = \prod_{(a_i,a_{i+1}) \in p(a_1,...,a_n)} T_{a_i\ a_{i+1}} \qquad (1)$$

In identifying the optimal social trust path that yields the most trustworthy result of trust propagation, different from existing works [2], this aggregated trust value is combined with the social intimacy degree and the role impact factor in selecting the optimal social trust path.

3.2.2 Social Intimacy Degree Aggregation

In the real-world, the intimacy degree is attenuated fast when it is approaching one. In contrast, the intimacy degree is attenuated slowly when it is approaching zero. Namely, the attenuation of social intimacy degree is non-linear in social networks [5].

The aggregated r value in path $p(a_1, ..., a_n)$ can be calculated by Eq. (2).

$$r_{p(a_1,...,a_n)} = \frac{\prod_{(a_i,a_{i+1}) \in p(a_1,...,a_n)} r_{a_i\ a_{i+1}}}{\theta^\alpha} \qquad (2)$$

where θ is the number of hops of path $p(a_1, ..., a_n)$, $\alpha \geq 1$ is used to control the attenuation speed.

3.2.3 Role Impact Factor Aggregation

In this paper, we average the RIF values of intermediate recommending agents in a social trust path $p(a_1, ..., a_n)$ as the aggregated value as in Eq. (3)

$$\rho_{p(a_1,...,a_n)} = \frac{\sum_{i=2}^{n-1} \rho_{a_i}}{n-2} \qquad (3)$$

3.3 Utility Function

In our model, we define the utility (denoted as $\mathcal{F}$) as the measurement of the trustworthiness of social trust paths. The utility function takes the QoT attributes T, r and ρ as arguments as in Eq. (4)

$$\mathcal{F}_{p(a_1,...,a_n)} = \omega_T * T_{p(a_1,...,a_n)} + \omega_r * r_{p(a_1,...,a_n)} + \omega_\rho * \rho_{p(a_1,...,a_n)} \qquad (4)$$

where ω_T, ω_r and ω_ρ are the weights of T, r and ρ respectively; $0 < \omega_T, \omega_r, \omega_\rho < 1$ and $\omega_T + \omega_r + \omega_\rho = 1$.

Thus, the goal of optimal social trust path selection is to select the path that satisfies multiple QoT constraints and yields the best utility with the weights specified by the source agent.

4. CONCLUSION

In this paper, we have presented the complex trust-oriented social network structure reflecting the real-world situations better. In addition, we propose a novel concept, Quality of Trust (QoT) and a utility function for social trust path selection in complex social networks.

5. REFERENCES

[1] P. S. Adler. Market, hierarchy, and trust: The knowledge economy and the future of capitalism. *Organization Science*, 12(12):215–234, 2001.

[2] C. Hang, Y. Wang, and M. Singh. Operators for propagating trust and their evaluation in social networks. In *AAMAS'09*, pages 1025–1032.

[3] G. Liu, Y. Wang, and M. Orgun. Trust inference in complex trust-oriented social networks. In *IEEE CSE'09*, pages 996–1001.

[4] A. Mccallum, X. Wang, and A. Corrada-Emmanuel. Topic and role discovery in social networks with experiments on Enron and academic email. *Journal of Artificial Intelligence Research*, 30(1):249–272, 2007.

[5] R. Miller, D. Perlman, and S. Brehm. *Intimate Relationships*. McGraw-Hill College, 4th edition, 2007.

[6] F. Walter, S. Battiston, and F. Schweitzer. A model of a trust-based recommendation system on a social network. *Autonomous Agents and Multi-Agent Systems*, 16(1):57–74, February 2008.