My research studies trust-based coordination among agents in dynamic, open systems. Such systems arise. Modern systems (e.g., service-oriented systems) embrace a distributed setting where a system consists of multiple autonomous parties. These individual parties have their own goals and achieve them by interacting with each other. Trust provides a basis for effective interaction, helping agents decide which parties to rely upon for taking a particular action. My research aims to (1) build trust models that enable agents to estimate trustworthiness of parties (learning), and (2) develop approaches for agents to make effective predictions and decisions based on trust information (mining). My goal is to establish "soft" security among agents to facilitate decentralized coordination in multiagent systems. Applications of my research include service-oriented computing, social networks, cloud computing, sensor networks, robotic control, etc.

Trust for General Agents

Applying trust models in multiagent systems involves overcoming the following key challenges: (a) how to estimate trustworthiness based on direct experience, (b) how to aggregate indirect evidence from a third party, (c) how to evaluate trustworthiness of a third party based on trust information it provides, and (d) how to incorporate dynamic behavior. My research has built a probabilistic trust model, and shown that how the model estimates trustworthiness of a party through both direct or indirect evidence, and how the model maintains and updates estimated trust to reflect new evidence [5].

Trust for Service Selection

Below I discuss challenges that arise in two application areas. A natural usage of a trust model connecting with services is in selection. How can we select similar services based on their different quality? This can be divided into two questions. How can agents learn the qualities of services, and select services based on their learned quality and their individual preferences? Besides, an unique aspect in service-oriented computing is that services can be composed into composite services. How service selection takes compositions into account? For example, how agents learn quality of constituent services given composite quality, and how my approach guides agents to compose compositions? My research has used a statistical model to estimate the trustworthiness and contribution of constituent services given observations of composite quality [2]. Also, I have combined my trust model with utility functions mapping quality to utility to capture preferences of agents or compositions [1].

Trust in (Social) Networks

Once an agent builds trust relations with its acquaintances, how does the agent use these relations to achieve desired coordination? An intuitive answer is to interact with the acquaintance with the most trust value. However, normally the trust relations of an agent are sparse—it only knows a small part of the population. This yields two problems: prediction and recommendation. An agent has to decide whether to interact with an unknown party (prediction). Or, the agent needs to find a stranger with potential high trust value (recommendation). To address these questions, the agent often not only looks at its acquaintances but also considers farther relations such as referrals or trust information provided by others. The agent collects all of the information as a trust network.

A trust network is a graph composed of parties and the trust relations among them. By mining the trust network, the agent can extract useful recommendations or predictions. Such recommendations and predictions are customized based on the agent and the context. For example, given a nonadjacent node (i.e., an unknown party), the agent can propagate trust through its trust network and estimate the trustworthiness of the nonadjacent node (trust propagation). Or, given a pattern, say, a path of length three (i.e., friends of friends), the agent can extract such pattern from its local trust network, yielding a prediction of potential friends (trust-based recommendation). My research has defined operators for propagating trust through a trust network [4]. For trust-based recommendation, I have adopted a graph similarity approach to make customized recommendations by retrieving patterns from a trust network [3]. I have evaluated these approaches on real datasets like PGP (trust), FilmTrust (movies), Advogato (trust), Epinions (reviews), MovieLens (movies), and Jester (jokes).

My trust-based recommendation is different from traditional graph mining in many ways. First, traditional graph mining treats edges weights as scalars, whereas in my context, I consider edge weights as trust values, which take advantage of my probabilistic trust model, providing not only a probability scalar, but also a confidence measure, propagation operators, and the update method. Second, a traditional graph mining usually is designed specifically for

a particular context. For example, a social recommendation can be significantly different from a movie recommendation. However, my trust-based recommendation aims to provide a general framework, which can be customized by using multiple trust relation patterns. These patterns are decided based on the context. Note that the trust-based recommendation cannot avoid optimization against the context, but it provides a unified framework for various types of graph mining problems.

Future Research

In my long-term research, I plan to explore both theories and applications in trust-level coordination in multiagent systems. Besides the projects described above, I am interested in four particular topics: trust mining in (social) networks, contract-based coordination, trust-based decision making, and utility-driven mechanism design.

Trust Mining in (Social) Networks In addition to trust propagation and trust-based recommendation, my research direction of this area is threefold. First, I aim to provide various recommendations for different contexts. Second, I plan to suggest effective patterns for each context, such as which pattern can be used for which problem. Third, I will study the properties that can guide agents to choose appropriate trust mining approaches.

Contract-Based Coordination In reality, coordination is often contract-based. For example, in a service-oriented setting, how an agent decides an appropriate contract length to sign with a service provider to avoid (1) service unavailability caused by competition after a short contract, and (2) utility loss caused by uncertain future availability of the service given a long contract. I plan to devise a utility-driven approach built on my trust model to address contract-based service selection problem.

Trust-Based Decision Making Most existing trust models study how to estimate trustworthiness accurately. Yet, the applicability of these models is limited because they fail to provide a guideline for decision-making. For example, a party with how much trustworthiness is safe to interact with? How much evidence is sufficient to yield an answer of yes or no? To answer these questions, I plan to explore how this sufficiency can be related to the properties (e.g., sparsity) of, for example, the system or application. These answers can not only help decision-making, but also guide agents to choose appropriate models in different circumstances.

Utility-Driven Mechanism Design One of the goals of using trust models is to incentivise self-interest agents. However, in many cases, agents can manipulate trust mechanisms by colluding, white-washing, free-riding, etc. Many trust mechanisms are studied to protect systems against such attacks. However, in some domains, such mechanisms are still limited. For example, a strategic service can manipulate a composition by providing the lowest quality that is not affecting the overall quality, or sign forever long contracts with the best provider in a contract-based scenario. Answering these questions can help the community build more intelligent open systems.

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