Sub-delegation and Trust

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Abstract—We investigate trust propagation in delegation situations, which often occur in hierarchical organisations and coalition structures. In doing so we define a delegation chain representing the sub-delegation process. Such delegation chains present a problem for current trust evaluation mechanisms, which are unable to accurately divide trust among the chain members, resulting in degraded system performance. In this paper we investigate the effects of sub-delegation on a probabilistic trust model and propose a model of weighting trust updates based on shared responsibility. We evaluate this model in the context of a simulated multi-agent system and describe how different weighting strategies can affect probabilistic trust updates when sub-delegation is possible.

I. INTRODUCTION

Trust is a critical feature in coalitions, with members often acting based on their trust in other members, and a large amount of literature exists on mechanisms for computing — and acting based on — different trust levels between agents [3], [4]. Such systems have been shown to improve the overall utility of the MAS, with poorly performing agents quickly garnering a low trust rating, leading to others minimising their interactions with them, thereby reducing the potential harm such untrustworthy agents can cause to the system.

Trust is critical for the successful delegation of tasks, whereby one agent requests that some other agent execute a task on the first agent’s behalf. Most existing trust mechanisms assume that interactions affect only the truster and trustee, and ignore the possibility of a task being repeatedly delegated from one agent to another. We refer to this sequence of delegations as a delegation chain, with the agent originally desiring the execution of the task at the head of the chain, the agent executing the task at its tail, and intermediate delegators between them. Such chains appear in a variety of applications. The core question we seek to address in this paper is how the process of delegation (and sub-delegation) should affect trust measures.

For example, if the agent at the end of a delegation chain fails to achieve the delegated task, all agents in the chain should share some of the blame. Several intuitive ways of apportioning this blame exist, and we investigate the effects of each of these approaches on the system as a whole. In doing so, we describe and evaluate a model for updating trust in the presence of delegation. Our approach consists of a weighting scheme which discounts the change in trust placed in an agent based on the outcome of a delegated task and the agent’s position in the delegation chain.

As an example, consider a coalition partner requesting that another partner gather intelligence in some area. This second partner could then ask its local contacts to do so. If the intelligence gathering fails, the latter entity could explain that this was due to the local contacts being unreliable. The original requestor could accept this and not reduce their trust in the partner’s capabilities. However, the requestor (and second partner) would probably both trust their local contacts less after such an interaction.

II. APPROACH

We evaluate different weighting measures over a simple model of delegation. Our system consists of a set of agents, each of which are capable of performing some tasks. Agents also have communication links to other agents, and, if they choose not to perform a task, can request that some agent with which they can communicate, perform the task. Now in order to encourage delegation, we assume that agents have different levels of competence in performing different classes of tasks. When an agent must perform some task, they can deal with it in one of three ways, namely 1) decline the task, 2) delegate the task to another agent, or 3) perform the task. Deciding between these three courses of action is done based on the agent’s own capabilities, and the trust it has in the agents it communicates with. The same task can be repeatedly delegated, creating a path of agents responsible for its fulfilment, which we refer to as a delegation chain.

We use Jøsang’s simple Subjective Logic based trust model [5] in order to simplify our experiments and to highlight our contribution. Note that we leave the

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1This paper reports on work originally presented in [1]
repetitional dimension for future work – agents do not obtain third-party opinions through communication.

Existing approaches to trust apportion blame without considering delegation. That is, the trust of the delegator in the delegatee would be updated without considering other agents in the delegation chain. In such cases, we argue that trust updates should take into account the level of responsibility for an outcome, as reflected by their depth in the delegation chain.

We evaluated several different trust update mechanisms, which allow an agent to update its trust rating in all subsequent agents in the chain. These mechanisms weight trust based on position in the delegation chain, and are as follows: Uniform Weighting, where a responsibility is distributed evenly among all in-chain agents; All-First/Last Weighting, where all weight is applied to the first/last agent; Increasing/Decreasing Weighting, where increasing/decreasing proportions of weight are applied to consecutive agents in the chain; and Full Weighting, where all agents receive full weight. Intuitively, we seek to weigh trust according to an agent’s responsibility for the final outcome, and evaluate the performance of different models of responsibility.

III. Evaluation and Discussion

The different trust update mechanisms were evaluated via simulation. Agents interact over a number of rounds with partners of varying trustworthiness. Figure 1 shows the performance of the system (with respect to global utility) when using different weighting functions. The Decreasing and AllFull weighting functions appear to perform best.

While it appears attractive, the AllFull model is problematic as it is inherently unfair; intermediate agents are penalised (or rewarded) as if they performed the task alone. While this leads to a rapid convergence of performance, strategically minded agents could collude to abuse this approach. For example, agents pass a task around unnecessarily within a group, before finally delegating to a highly trusted individual, so that each agent in the group receives a full positive trust update without having to perform the task. Using the Decreasing mode prevents this possibility, as each sub-delegation reduces the weight applied to each agent in the chain. Investigating such strategic aspects of each weighting function will form one area of future work.

Our approach places few constraints on the particular trust model used, requiring only that the model permits discounted or weighted update. This already occurs in many trust models [4], which use discounting to reduce the impact of older experiences on trust assessments, allowing trust models to handle dynamic behaviour.

As future work we intend to examine how partial observability of the delegation chain can be dealt with. We also intend to investigate more complex delegation behaviours between agents (e.g. task splitting).

IV. Conclusions

This research addresses a new and exciting aspect of trust in multi-agent systems, namely how trust should be updated in the context of delegation. Such an approach has many practical applications. In both human and computational domains, one could ask how contractors should trust each other when tasks may be “outsourced” to other parties, and when trustors may be unable to control or observe this outsourcing process. In such situations, our model allows one to apportion responsibility between individuals in a fine grained manner, leading to improved overall system behaviour. We have shown that the choice of weighting function significantly affects the utility of the system. While our approach goes some way towards addressing delegation, it forms only a first step in investigating this aspect of trust, and many exciting avenues of future research remain open.

References