An Hybrid Trust Management Model For MAS Based Trading Society

Maarof M. A.[1] and Krishna K.[2]

[1, 2] Information Security Group,
Faculty of Computer Science and Information System
Universiti of Technology Malaysia, 81310 Skudai, Johor, Malaysia.
[1] maarofma@fsksm.utm.my,
[2] kana_boy@lycos.com

Abstract. The widespread use of the Internet signals the need for a better understanding of trust as a basis for secure on-line interaction. In this paper we provide and discuss existing works on trust management models in the area of Multi Agent Systems and highlight the shortcomings. Our proposed model is not presented as the final solution to the issue. This new model will have a mechanism that allows agents to manage trust not by just one way but a few combinations of different types of trust in different situations. The proposed model is concerned with the general notion of trust, one that goes beyond cryptographic protocols. Findings from this paper can be used for future research work in the area of trust in Multi Agent Systems and to address further the importance of trust management on the Internet.

1 Introduction

Internet services are increasingly being used in daily life for electronic commerce, web-based access to information and inter-personal interactions via electronic mail rather than voice or face-to-face, but there is still major concern about the trustworthiness of these services. There are no accepted techniques or tools for specification and reasoning about the trust [1]. The concept of trust may seem a little unusual to suggest for computers; it is thus worthwhile to put forward some reasons why it may prove useful. Implicit in the notion of distributed artificial intelligence is the concept of decentralization. Since decentralization implies a lack of central control, and with it lack of guidance in the right direction, it becomes necessary, in order to carry through successful interactions with other agents, to develop some judgement as to the worth of these interaction and the risk associated with them [3].

Software agents are increasingly being required to make decisions and act locally, but also operate in the context of a "global" multi-agent society. As these agents become fully autonomous they become forced to make decisions about when and when not to engage (for instance to request information, to delegate important tasks or to trade) with or trust other Agents. They must rely on beliefs and knowledge about those other Agents in the society. This reliance on beliefs forms the basis *trust rela-*

tionship between intentional entities [5]. Well known techniques to ensure that something is 'trusted' have been developed and strengthened, and these techniques include cryptographic algorithms, authentication protocols, and access control [2]. These methods cannot manage the more general concept of 'trustworthiness' and are currently lacking the complementary tool for managing trust effectively [6]. It is the aim of this research, to create a new trust management model through a hybrid approach that more comprehensively and realistically deals with the problem of trust, with particular emphasis on the specification and analysis of trust relationships.

We will continue in part (2) by clarifying our concept of trust, agent, multi agent systems. Part (3) will discuss previous work done. Part (4) will be on the justification for an hybrid approach and we provide an outline of our approach. The last part, (5) will be the summary, conclusion and future work of this research.

2 Background

This section will discuss the important terms involved in this paper and also discuss previous work done in this area.

2.1 Trust

Trust is a vast topic that incorporates trust establishment, trust management, and security concerns. Trust within entities is an extremely complex and dynamic phenomenon [7]. The lack of consensus with regards to trust has led authors to use the terms trust, authorization, and authentication interchangeably. The outcome of a trust decision is based on many things such as the trustor's propensity to trust, and its beliefs and past experiences relating to the trustee. For this paper, the term trust will be based on the definition by Tyrone Grandison that states [8]:

"Trust is the firm belief in the competence of an entity to act dependably, securely, and reliably within a specified context" (assuming dependability covers reliability and timeliness).

The earliest work on trust focused on individuals and used a psychological perspective [9]. From the research done on trust, we categorized it into three main elements that consist of *objective trust*, *subjective trust* and *reputation*. Objective trust can be seen as a form of absolute reliability in the subject of trust, which is based on attitudes, personality and previous experiences, to trust other people. Subjective trust is the mental state that influences the behaviour of an individual and is mediated by the specific nature of the transaction [10]. Some trusts are based on reputation of a particular agent. The definition of reputation for this paper will be based on Ostrom's [15] work that states:

"Reputation is the perception that an agent creates through past actions about its intentions and norms."

2.2 Trust Management

In [1], trust management is defined as:

"*The activity of collecting, codifying, analyzing and presenting evidence relating to competence, honesty, security or dependability with the purpose of making assessments and decisions regarding trust relationships for Internet applications*".

The definition above will be used for the purpose of this paper. This paper is not focused on Internet applications alone, which is mentioned in the definition but more on a general approach. Although this is the case, the definition also specifies the need to collect (*recommendation* and *objective trust*) and analyze to make decisions on trusting an entity. This is an important element in our approach. Trust can form an important factor in decision-making [18-20]. Thus, for Internet commerce or trading to achieve the same levels of acceptance as traditional commerce, trust management has to be an essential part of virtual communities.

2.3 Agent and Multi Agent Systems

An agent can be a software object, a robot, a living being, or anything that fulfills the basic concepts of agency. In the context of this paper, the use of the word *agent* will always imply *software agent* as opposed to any other kind, unless specifically stated. The following definition from [11] of an agent, will be used for this paper:

"*A software object that perceives its environment through sensors and acts upon that environment through effectors to achieve one or more goals*."

Combining several agents pursuing the same goal leads to the multi-agent system [12]. Similar to the term *agent*, it is difficult to find a commonly accepted definition of MAS. For the purposes of this paper, the Weiss definition of MAS will be used [13]:

"*A system in which several interacting, intelligent agents pursue some set of goals or perform some set of tasks.*"

2.4 Previous Work

This section looked into previous work done in the areas related to trust in Multi Agent Systems. From the survey done, a few shortcomings were identified in previous work done on trust management in Multi Agent Systems:

- Concentrated more on the security and cryptographic aspect [16].
- Most of the work were more general and concentrated more on trust in distributed environment rather than specifically of its application in a MAS environment [2, 4, 6].

- Concentrated on a specific type of trust either objective, subjective or reputation based trust only, rather than combining all as one which will reflect a more appropriate way of forming trust in a multi agent community [2, 5-6].
- Models that are complex, time consuming and laborious [1, 4, 9].

The new model will highlight and approach the shortcomings identified by:

- Concerning with the general notion of trust, one that goes beyond cryptographic protocols.
- The new model was built specifically for Multi Agent System environment.
- The model will encompass all three components of a trust based trading relationship, reputation, subjective trust and objective trust. This new model will have a mechanism that allows agents to manage trust not by just one way but a few combinations of different types of trust in different situations.
- The model is designed not to be too complex and laborious. Trust chain has been avoided for its complexity. Direct trust has been used for our approach.

3 Our Approach

It can be said that an effective practical trust model for the virtual environment is not yet in existence [4]. In most of the work on multi agent trust management surveyed, there is no mechanism that gives an option to have different combinations of trust for different situations. This will be the main concern of our work. For the purpose of this paper, we chose to go for a hybrid approach to combine the benefits of few models into one to make it more effective. The new trust management model will be based on the Witkowski M, *et. al* [5] *objective Trust-Based Agents* and Abdul-Rahman *et. al* [2, 4] distributed trust model. The former was chosen for its strong objective trust element and the latter for its combination of subjective trust together with reputation. The new model will encompass all three components of a trust based trading relationship, reputation, subjective trust and objective trust. Each has an important role to play at different times in the overall life of a trading partnership. This was stated in [5], as future work and it forms the motivation of our research. An additional mechanism that controls this three component will exist in this proposed model.

3.1 The Model

The proposed model in figure 1 has 3 main components consisting of objective trust-based agents, reputation and the trust mechanism. Together these components combine to form the trust opinion needed in decision-making.

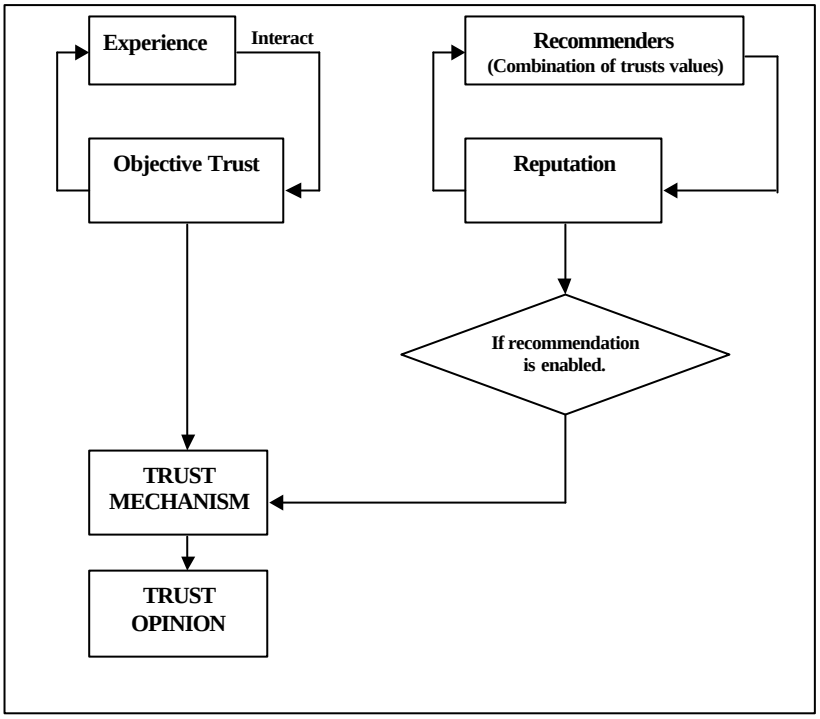


Fig. 1. Hybrid Trust Management Model.

Objective Trust. Each agent makes part of its trading decisions based on its past experiences of trading with other Agents in the system, updating its trust vector, and so affecting its future decisions, based on each new transaction. The function matches the intuition that trust is most enhanced by getting exactly what we requested, partially enhanced by getting some of our request and damaged by being excluded. The formulation also gives greater weight for recent experiences than earlier ones, the effect of past events are discounted with each new experience.

Reputation. Since it can be beyond each individual's resources to evaluate all aspects of a given situation when making a trust decision, agents must rely on other sources of information. For this model the recommendation element in a community is used to build reputation of a certain agent. This reputation is only used when trust ratings from based from experience is not sufficient. The flexibility of this model permits the reputation component to be enabled and disabled. Recommendation rating values from other agents will be combined to calculate reputation. To draw a consistent conclusion a way was identified in [4]. To maintain a strict trust management and lessen the implication of untrustworthy agents in the society a few rules are applied in this model for the reputation component. These are:

- Trust chain is not used.
- Only direct recommendation is accepted and ratings given from only one prior experience with an agent is not accepted.
- Recommenders are not selected based on ratings. All selected recommenders are assumed to be fully trustable, well known people with good judgement.

Trust mechanism. This is the most important component of this trust management model. It forms the core of the model. After the two components of objective trust and reputation has been calculated, it will be brought to the trust mechanism to form trust opinion/decisions. This mechanism allows agents to manage trust not by just one way but a few combinations of different types of trust in different situations. This mechanism works based on a set of rules. The algorithm of this mechanism is shown below in figure 2.

```
If (no previous experience) and (reputation component enabled)

    if (reputation sufficient)

        Use reputation;
    else
        Explore to get experience  based on exploration rate;

Else if (experience exist) and  (reputation component enabled)

    if (experience sufficient)

        Use both experience trust ratings combined with
        reputation if available;
    else
        Explore to get experience based on exploration rate;

Else if (experience exist) and  (reputation component disabled)

    if (experience sufficient)

        Use experience trust ratings only;
    else
        Explore to get experience based on exploration rate;
Else
    Explore to get experience based on exploration rate.
```

Fig. 2. Algorithm for the trust mechanism.

3.2 Model Architecture

The architecture of the proposed model is based on a distributed migration path. It uses a Master-Slave pattern, which is a common task design model, incorporated in a broad domain of parallel applications. This Master-Slave model is based on a divide and conquer strategy in which a master delegates tasks to one or more slaves that in turn are distributed throughout the system and work in parallel. The implementation of distributed migration path is considered to secure a prototype system because it has been implemented and tested by Kotzanikolaou *et. al* and has been successful in preventing attacks such as suppression of information [17], especially in MAS environment where agents travel from one destination to another.

The trust mechanism is controlled and executed by a customer agent who initiates a trading deal. The other two components of objective trust and reputation will be executed by two different slave agents generated by the customer agent before committing a trading deal with a certain trader agent. The customer agent acts as the master agent. The two slave agents are:

- OT agent (objective trust)
- Reputation agent

OT agent architecture. The architecture for the OT agents is shown in figure 3. Customer agent generates OT agents to get information from trader agents who are known through past experiences (in the database) to know whether they available in the sense that they have the capacity to accommodate the request. This OT agent generates more slave agents if there are more then one known trader agents. If there are no known trader agents who are available, then new agents are approached through the same approach of generating slave agents

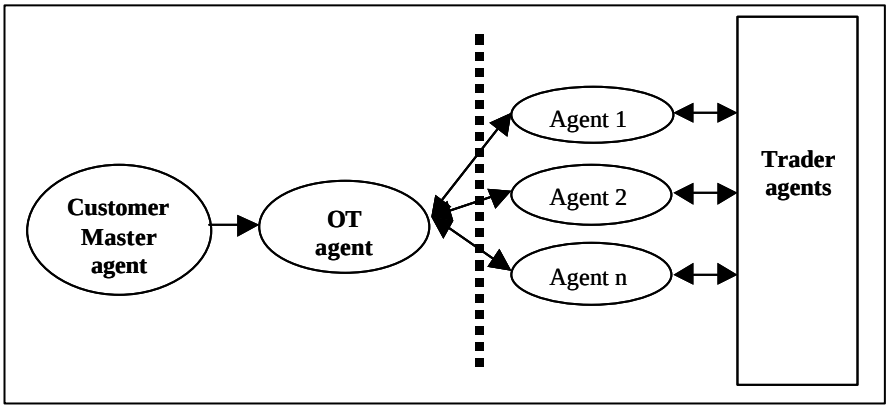


Fig. 3. The OT agent architecture.

Reputation agent architecture. The architecture for the reputation agents is shown in figure 4. The Reputation agents are only used if past experience with trader agents are not sufficient. Customer agent generates Reputation agents to get information from other trusted customer agents (in the database) to know whether they have available information on certain trader agent. This Reputation agent generates more slave agents if there are more then one known customer agents. After gathering reputation values from different customer agents, the Reputation agent calculates and sends the overall reputation of the trader agent to its master customer agents who requested it.

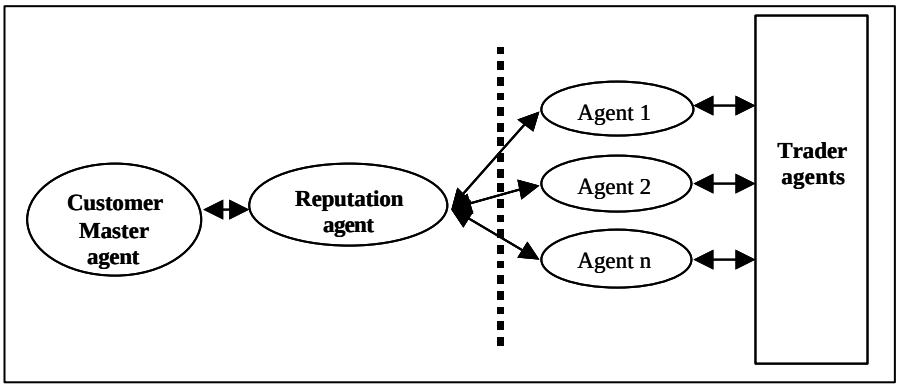


Fig. 4. Reputation agent architecture.

4 Conclusion and Future Work

This research contributes by proposing a new trust management model. Our approach is intended to complement current security practices by forming a general model within which trust can be more effectively managed and to extend trust beyond certification and encryption. Future research will attempt to carry out simulation based on the proposed model to test and study its behaviour pattern of the agents in different circumstances. Findings from this research paper can used for future research work in the area of trust in Multi Agent Systems and to address further the importance of trust management.

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