Time-Based Dynamic Trust Model Using Ant Colony Algorithm

0 Introduction

With the development of Internet-based services and applications proceeding at unprecedented speed, a mass application systems turn to distributing from centralizing. A practical problem is to implement the inter-operation between the different information sources, how to construct the trust relationship between entities in the complex distributed heterogeneous system that is a challenge for the researchers. Since Marsh[1] has imported trust research into computer area, trust mechanism has received more and more attention because of its flexibleness and extensibility. Many trust models[2] are proposed in a lot of areas such as distributed network, P2P computing, ubiquitous computing[3] and autonomous network[4].

In the traditional model of the trust relationship, trust was usually defined as a Boolean variable[5], that is to say, in the session of both trust entities, one trust another entirely, or absolutely not, there would never be a middle course. For instance, the entity A trusts entity B, but it is hard to tell how much they trust each other. Therefore, we have to quantify their trust intensity, so that we can define the meaning mentioned above. It is claimed in this paper that the trust intensity between entities is not fixed. In fact, the trust intensity is varied with the inter-operation and time lapse.

We propose a new dynamic trust relationship model that the trust intensity is the function of the time and the inter-operation events. In the model, the trust intensity will be described by the trust-degree, base on the mind of the ant colony algorithm. Ant colony algorithm is a kind of simulated evolution algorithm based on the research on the ant colony’s behaviors in the nature. Although single ant’s behavior may be too simple, but colony of these simple ants may behave in a
complex way and complete intricate tasks. Moreover, ants may respond to the change of environment. For example, when encountering an obstacle in their route, ants can find optimal detour route quickly. People find that ants communicate with each other through so-called pheromone matter to collaborate to cover tasks.

As described in ant colony algorithm, when an ant passed a way, it has left some pheromone in the way. When more ants pass the way, the pheromone's amount in the way is stronger and stronger. Adversely, if there is no ants pass the way, the pheromone's amount in the way will reduce after a while. Colorni and Dorigo et al. [5, 7] proposed the method to formalize the change of the pheromone. And we think that the trust intensity is quite similar to the pheromone. For example, the fact that the trust intensity will increase when two entities have an inter-operation is similar to the increase of the pheromone in a way. Furthermore, as mentioned above, the condition of the decrease of the pheromone in a way is similar to that of the reduction of the trust intensity between entities.

Based on the mentioned above, we propose the trust-pheromone similarly. Every inter-operation between two entities in the system can increase their trust-pheromone, and the trust-degree will decrease with time passing by. If the two entities have not communicated with each other for a long time, the trust-pheromone will decrease correspondingly.

1 TDTM Model

1.1 Entity’s Trust Relation

Definition 1 Trust-degree describes entity’s trust level, it can be represented as $p_{ij}(t)$, its value ranging between 0 and 1. $p_{ij}(t) = 0$ expresses that the entity i and entity j don’t trust each other at time $t$, and $p_{ij}(t) = 1$ expresses that the entity i and entity j trust each other completely at time $t$, respectively.

Definition 2 Trust-vector notes the trust-degree between this entity and others suppose there are $n$ entities in the distributed environment, and then every entity has a local trust vector:

$$p_i(t) = (p_{i1}(t), p_{i2}(t), \cdots, p_{in}(t))$$

(1)

This vector is the function for inter-operation event and time. If entity i and entity j have inter-operation at time $t$, then the trust-degree between the two entities will increase, it as follows:

$$p_{ij}(t) > p_{ij}(t-1)$$

(2)

After a lapse of interval, the trust-degree between any two entities will decrease tardily, if they have not any inter-operation in a quite long time, the trust degree will change to zero, and that is to say the two entities will have not any trust each other.

When system initializes, every entities’ local trust vector will be confirmed, it is described as $p_i(0)$. The policy we adopted is as follows:

If the whole distributed system is under a CA that is a hierarchy, and when the two entities under the same CA, the trust degree between them is 1, reversely it is zero.

If the CA configuration is a reticulation, and when there is a trust path between the two entities, the trust degree between them is 1, reversely it is zero.

1.2 Description of Dynamic Trust

In order to make the increase and reduce of the dynamic trust between two entities numeric, we introduce trust-pheromone.

Definition 3 Trust-pheromone describes the base factor between two entities, let $r_{ij}(t)$ be the trust-pheromone between entities $i, j$ at time $t$. Under the initial condition, we can set the value of the trust pheromone between entities by practice case, possibly, we let the trust-pheromone equal at the beginning, let $r_{ij}(0) = C$ ($C$ is a constant). If the trust-degree between entities $p_{ij}(0) = 0$, then $r_{ij}(0) = 0$.

And we assume that $\eta_{ij}$ is the trust-transparency [8], this paper definite that it is the heuristic information that a entity trust in another, we set $\eta_{ij} = 1/d_{ij}$, $d_{ij}$ is the distance between entity i and entity j, $\alpha$ is the trust information’s weightiness in the path from i to j, $\beta$ is the weight of heuristic information(whose initial value is base the actual case).

According the pheromone’s expressions in ant colony algorithm [9, 10], at time $t$, the trust-degree between entities is defined as:

$$p_{ij}(t) = \rho p_{ij}(t) + \sigma r_{ij}(t) + \sum_{i,j} \tau_{ij}(t)^\alpha [\eta_{ij}]^\beta$$

(3)

If there is no inter-operation between entities, the strength of trust-pheromone between two entities will decrease tardily, let $1 - \rho$ be the diluteness of trust-pheromone intensity, and $\sigma r_{ij}$ be the additional trust-pheromone intensity at each inter-operation between entities,

$$\tau_{ij}(t + n) = \rho \tau_{ij}(t) + \sigma r_{ij}$$

(4)