

The Trust Model of Virtual Team:

Organizing Method Bases on the Agent Relation Network

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Abstract—A virtual team is different from a traditional team, and it lays emphasis on trans-time, -space and -organization-boundary, which makes the trust between individuals become a challenge to enhance performance and achievement of a team. It has long been a hard issue for the virtual team researchers to set up a trust system. After systematically analyzing the intrinsic meaning and concept model of the trust, this paper proposes the trust based on recognition of a virtual team, and introduces an Agent network model, so as to establish a trust model between individuals. The quantitative descriptions on the trust relationship among the Agents are also presented in the paper.

Keywords- *Virtual team; trust system; open multi-Agent system; Agent relation network model*

I. INTRODUCTION

A virtual team is an organization mode with dynamic, flexible and high efficiency cooperation and with a project as a center. It utilizes networks and information technology to connect persons in different locations and organizations together to complete a concrete task [1]. Different from a traditional team, it lays emphasis on trans-time, -space and -organization-boundary and carries out communication and cooperation by means of modern communication technology. These features of the virtual team make the trust between individuals facing bigger challenge than the traditional team.

A large amount of research found that nice trust relation could promote communication in a virtual team and improve performance and achievement of all the team. A believable communication mode has become an obvious feature and one of critical factors that the team succeeds, and establishment and maintenance of the trust is regarded as a core issue of management of the virtual team [2]. On the one hand, the virtual team is a team with a project as the center, which requires that the team has ability to rapidly and flexibly complete tasks and demands nice trust and cooperative relation between individuals; on the other hand, long-term stable communication is the foundation for the trust and cooperative relation. Such two aspects cause inherent, so-called “Absurdity” and “Problem” to establish the trust relation in the virtual team [3]. Uncertainty occurs in the individuals in a virtual team. The more the uncertainty is, the lower the trust degree between the individuals is. In addition, because of shortage of face-to-face communication and valid organization

management in the traditional teams, the trust relation is easy to set up and to lose. How to effectively set up and maintain the trust relation and to realize valid communication between the individuals becomes an important problem that has to be resolved for management of the virtual teams.

II. TRUST SYSTEM OF A VIRTUAL TEAM

Trust is a kind of complicated social psychological phenomenon and concerns multi-layers and dimensions and should be studied in multiple respects. Among them, research on psychology and social praxiology is the deepest and relative definitions of the trust may be divided into “Faith” and “Action Interaction”. The former considers the trust as expectations to acquire the professional knowledge and reliability of the other party; the latter explains the trust as an action temptation and reflects the dependency of one party to the other party. In general, the trust is “Basic psychological characteristic in cooperative demand with others” with easy losses, risks and uncertainty. Ajzen et al. proposed a theory of reasoned action (TRA) [4], which supposed behavioral intention was driven by belief, attitude, and result assessment, etc. Based on the former works, Mager et al. deeply analyzed the meaning of trust, and set up a trust concept model in organizations, which composed three layers: trust faith, trust intention and trust action [5]. Besides, Sheppard et al. proved, through elemental analysis, that the TRA model has predictive ability for the faith action [6].

The virtual team is a new type of specific organization, where the trust between the individuals is especially significant in driving the team achievement by means of their communication and cooperation, and a successful virtual team shall care for the trust issue at each stage of the team development. The trust between the individuals in a team can simplify human complicity in social actions and add confidence and security in relations, so as to promote complete and open information interaction and reduce costs for communication and cooperation in a virtual team. The trust as a social capital is a kind of capital itself and can increase cooperative opportunities to obtain treasure [7].

Despite in social praxiology or psychological field, the trust is traditionally considered as multi-dimensional; including recognition factors based on ability, reliability and profession and feeling factors based on concern and emotional connection

with others, and the relative importance in these two respects will differ in different relation types between persons and actual situations. The objective of a person in a virtual team is to complete concrete tasks but not to set up social relations, and the individuals are treated in view of recognition factors, instead of feeling factors. Therefore, establishment and maintenance of the trust in a virtual team depends on the recognition of the trust.

In summary of above mentioned, there is close relation among the trust, communication, cooperation and team achievement between the individuals in a virtual team. The trust based on recognition is a core characteristic of the trust in a virtual team and this trust relies on individual cooperative efficiency and effectiveness in the team to transfer, in which the cooperative efficiency depends on intensity of the individual ability and the cooperative effectiveness depends on reasonable allocation of the tasks. Hence, construction of the trust in a virtual team must follow the trust principle based on the recognition.

III. PROBLEMS PROPOSED

Since the trust relation in the virtual team is so elusive, how to constitute effective, quantitative and believable communication models has become a problem worth studying in the virtual team [3]. At first to investigate a process how acquaintances in real society resolve individual problems: when a person encounters problems, at the beginning he tries to resolve them with his own ability; otherwise, he looks for his acquaintances to assist him to resolve them; if after that, the problems could not be resolved yet, his acquaintances will look for their acquaintances to resolve, which will last until the problems are resolved. So, sum of all the acquaintances around solution of those problems constitutes a so-called "Relation Network", which is a typical example of the virtual team that this paper studies.

Through analyzing the above mentioned process that relation network is constituted, it could be found that this process is actually a multi-agent system (MAS) solution process. MAS is an artificial intelligent method to resolve distributed system problems by means of information dissemination and task allocation among various Agents. In MAS whether in task allocation process or information dissemination process, the core is an information exchange process among the Agents [8, 9]. A large amount of research indicates that MAS, as an effective tool to resolve distributed system problems, can better resolve problems without strict organization limitation and can establish valid communication modes through a relation model, which specially presents other Agents' resource and ability [10].

This paper follows the construction policy of the trust in the virtual team and the principle based on the recognition to design an open multi-agent system (OMAS). In the structure of OMAS, the Agents, through a self model, shows the Agent's self information and a relation model to present other Agents information — Agent address lists. When an Agent gets a task, he assesses himself at first; when he could not complete the task independently, he assesses various related Agents by means of the address lists and decides to ask for cooperation

from proper related Agents. In the OMAS, information dissemination among the Agents describes that the virtual team shares the recognition ability by communication, and task allocation indicates the reasonable separation of project by the cooperation between individuals in the virtual team. As for virtual team is a team with concrete tasks as its objectives and without strict organization limitations, OMAS simulates that it constitutes a relation model to use the Agent address lists to describe other individuals' recognition ability in the team to facilitate the task arrangement and set up effective believable communication ways between the individuals in the team.

Section IV in this paper presents the Agent data structure and basic definition. Section V explains in detail the trust constitution method between the Agents concerning the system structure, trust characteristic database and trust system of the Agent relation network. At the last conclusions about the research work are given in section VI.

IV. BASIC DEFINITIONS

According to the individual features in virtual team, the Agent's attribute mainly contains *Name*, *Address*, *Capability_List* and *Contact_List*. *Name* indicates the Agent mark symbol. *Address* indicates the Agent contact method, and in the computer networks it can be the style of IP:Port. *Capability_List* denotes the Agent's ability to resolve problems, which is really a complicated vector structure, including the Agent's multiple kinds of ability and its assessment indexes in several fields and their relations. *Contact_List* presents the Agent's address lists, basically through which the Agents realize task separation and solution by valid believable communication between the individuals. This structure is discussed in detail below.

The *Contact_List* gives all information of the related Agents. The address list of the Agent with Name *a* may be expressed as $\text{Contact_List}(a) = \langle L_1, L_2, \dots, L_n \rangle$. L_i in the list represents a relation record and records a mark symbol, contact way, trust degree, relation and ability etc. of No. *i* related Agent, such as $L_i = \langle \text{Name}, \text{Address}, \text{Trust_Degree}, \text{Rel}, \text{Cap} \rangle$, where the range of the trust degree is (-1, 1) and it mainly depends on the *Capability_List* of the related Agent, which is related to the trust relation between the Agents in the Agent relation network. The higher the trust degree is, the bigger the cooperative opportunity with the related Agents is. Section V will give an assessment system and quantitative calculation of the trust degree.

Definition 1 Acquaintance: given two Agents *a* and *b*, if $b = \text{Contact_List}(a).L_i.\text{Name}$, then it is said that *a* knows *b* and it can be recorded as $\text{Acq}(a, b)$.

Definition 2 Relation: given two Agents *a* and *b*, if $\text{Acq}(a, b)$ and $\text{Acq}(b, a)$ occur, then we can say *a* and *b* have relation and it can be recorded as $\text{RA}(a, b)$. All Agents that have relations with *a* compose a Set called Relation Ring of *a*, recorded as $\text{RA}(a)$, which is the base of the relation network.

Obviously, the Relation is of reflexivity, symmetry and non-transitivity, i.e., $\text{RA}(a, a)$ and $\text{RA}(a, b) \equiv \text{RA}(b, a)$ are provable, but if $\text{RA}(a, b)$ and $\text{RA}(b, c)$ are true, we can not deduce $\text{RA}(a, c)$.

V. TRUST SYSTEM STRUCTURE BASED ON THE AGENT RELATION NETWORK

A. Trust system structure

Based on the organization mode of the virtual team, in view of the trust and according to the structure of the relation network, a trust system model is proposed as Fig. 1, which contains three processes, i.e., trust management, relation management and trust constitution.

Among them, the trust management maintains the Agent trust characteristic database, based on which we can generate the relation trust and the ability trust. The relation management is responsible to maintain the Agent relation network, which is recorded and resulted in from the Agent relation network and divided into the Agent direct relation and the Agent indirect relation. The trust constitution is responsible to look for cooperative partners and selects cooperative partners with high trust degree when the Agent demands as well as responsible the trust establishment and maintenance, and meanwhile, supplies the trust security system to promote the trust establishment in the system. For the trust constitution, the relation database and trust characteristic database denotes the same data system as different roles in different management.

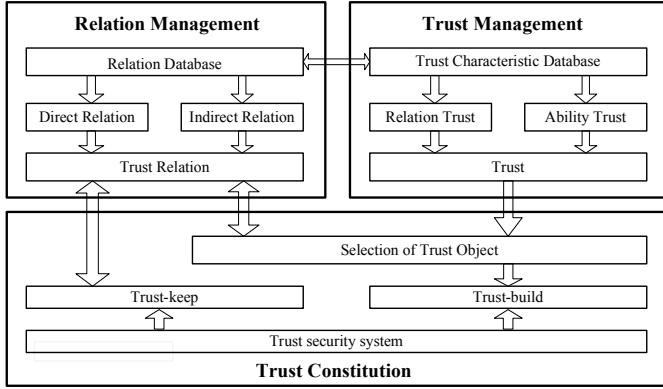


Figure 1. Trust system model based on the Agent relation network

B. Constitution of the trust characteristic database

The trust characteristic database records the trust assessment indexes of all the related Agents in the relation ring of the Agent a , including the Agents' multiple ability, its assessment indexes in a few respects and relation of various indexes, from which the trust management produces the trust degree of the relation Agents and the relation degree from their adoption frequency, then, calculates their trust degree and records it in the address lists. Description in Table 1 explains structure of the record table of some related Agent b .

(1) Calculation of b 's ab_i

$$Cap(ab_i) = \alpha Cr + \beta Et + \chi Er + \delta En \quad (1)$$

Where $Cap(ab_i)$ is ability intensity, α , β , χ and δ are respectively weights of various assessment indexes.

TABLE I. RECORD TABLE OF RELATED AGENTS

Description of ability	Agent's assessment on validity	Time efficiency	Resource efficiency	Quantity efficiency	Use frequency
ab_1	Cr	Et	Er	En	Uc
ab_2	Cr	Et	Er	En	Uc
\vdots	\vdots	\vdots	\vdots	\vdots	\vdots
ab_n	Cr	Et	Er	En	Uc

(2) Calculation of b 's entire ability

$$Cap(b) = \sum_{i=1}^n \alpha_i Cap(ab_i) \quad (2)$$

Where $Cap(b)$ is the related Agent b 's ability intensity and n is the Agent's ability quantity, and α_i indicates weight of ab_i in various ability.

(3) Calculation of relation degree

Definition 3 Relation degree: if $RA(a, b)$ occurs, a relation degree between a and b occurs, recorded as $Rel(a, b)$, so

$$Rel(a, b) = \alpha_1 Use(a, b) + \alpha_2 Use(b, a) \quad (3)$$

$$Use(a, b) = \sum_{i=1}^n \alpha_i b.ab_i.Uc \quad (4)$$

In (3), α_1 and α_2 are relation weights, depending on leading position of a and b in the relation; $Use(a, b)$ indicates adoption frequency of a to b . In (4), α_i indicates ab_i weight of various ability of b . If Uc exceeds range value Uo , it is considered that a fully utilizes b 's ability ab_i , when $b.ab_i.Uc = 1$. Obviously, the relation degree like the relation is of reflexivity, symmetry and non-transitivity. And we can define $Rel(a, a) = 1$, which indicates sufficient trust of the Agent to himself.

(4) Calculation of the trust degree

$$b.Trust_Degree = \alpha_1 Cap(b) + \alpha_2 Rel(a, b) \quad (5)$$

Where α_1 and α_2 are weights of the trust degree of relation and ability.

At last the b 's trust degree obtained is recorded in the a 's address lists, which addition rules are shown with the codes below:

```

a::Add_List(b)
{While(i!=n){//n is the scale of the address lists;
if (b=Contact_List(a).Li.Name){//if the b's record occurs
}
}
}

```

```

Contact_List(a).Li.Trust_Degree=b.Trust_Degree;// update
the trust degree

Contact_List(a).Li.Rel=Rel(a,b);// update the relation

Contact_List(a).Li.Cap=Cap(b);// update the ability

break;} else i++;}

Contact_List(a); //result a vacant communication record Ln+1,
and n=n+1

Contact_List(a).Ln+1.Name=b; // symbolic assignation of
communication record

Contact_List(a).Ln+1.Trust_Degree=b.Trust_Degree;// assignation of the trust degree

Contact_List(a).Ln+1.Rel=Rel(a,b);// assignation of the relation

Contact_List(a).Ln+1.Cap=Cap(b);// assignation of the ability

return succeed; }

```

C. Constitution of the trust

Constitution of the trust in the Agent's relation network mainly includes selection of believable partners and security system of the trust. Calculation for the believable partners is to find believable cooperative Agents, who meet the cooperative requirements and cost a bit lower, which advantages are to validly promote aggregation of the relation network and establishment of the trust within the relation network. For the Agents who never cooperate with any Agents in the system before, a bit high trust degree is given only at the first time for cooperation with other Agents, then, his trust degree depends on his performance of cooperation in the system. According to this principle, the following calculations are presented:

Calculation 1: Trust establishment in the relation ring based on the trust degree

```

a::find(ab,Td)// to look for cooperative Agent b with the highest
trust degree of ability ab in the relation ring;

for(i=1;i<=n;i++)// to look for RA(a), n=size of(RA(a)) is
quantity of related Agents in RA(a), initial value of i is 1;

{while(j!=m){// to look for ability vector of Agent bi and for
ability ab, m=size of(bj) is length of the ability vector;

if(ab!=bi.abj)j++; else break; }

if(Td<bi.Trust_Degree){ // if bi trust degree is higher than Td,
the believable Agent is recorded as bi, and update the trust
degree Td;

Td= bi.Trust_Degree; b=bi}

i++;} return bi;

```

Calculation 2: Trust establishment in the relation ring based on the ability

```

a::find(ab,cap)// to look for cooperative Agents with the highest
cap of ability ab in his relation ring;

for(i=1;i<=n;i++)// to look for RA(a), n=size of(RA(a)) is
quantity of related Agents in RA(a), initial value of i is 1;

{while(j!=m){// to look for ability vector of Agent bi and for
ability ab, m=size of(bj) is length of the ability vector;

```

```

if(ab!=bi.abj)j++; else break; }

if(cap<cap(bi.abj)){ // if bi.abj is greater than cap, the
trusted Agent is recorded as bb and update the ability
intensity cap;

cap=cap(bi.abj); b=bi

i++;} return bi;

```

Calculation 3: Trust establishment in the relation ring based on the resource limitation

```

a::find(ab,Er)// to look for cooperative Agent b with the highest
resource efficiency and ability ab in his relation ring;

for(i=1;i<=n;i++)// to look for RA(a), n=size of(RA(a)) is
quantity of related Agents in RA(a), initial value of i is 1;

{while(j!=m){// to look for the ability vector of Agent bi and
for ability ab, m=size of(bj) is length of the ability vector;

if(ab!=bi.abj)j++; else break; }

if(Er<bi.abj.Er){ // if bi.abj.Er is greater than Er, record the
trusted Agent as bb, and update the resource utilization rate
as Er;

Er=bi.abj.Er; b=bi

i++;} return bi;

```

The constitution process of the trust guarantees effectiveness of the trust: by means of the selection calculation of believable partners, it can select sufficient believable partners and record cooperative consequence into the characteristic trust database for open inquiry, and through information exchange inside the relation network, makes those with high trust degree obtain more cooperative opportunities.

VI. CONCLUSIONS

Introduction of the relation model not only fits for the trust requirement of the virtual team based on recognition, but also has the following advantages: at first it does not need to set up special agencies to maintain various Agents' information and reduces general costs of the virtual team with reduction of resource costs of the OMAS system; the second is to adopt whole distribution way to visit and maintain the Agents' information and to reduce the trust maintenance costs between the individuals in the virtual team through reduction of costs of OMAS to maintain the Agents' relation. The OMAS adopts the Agent relation network to pass the Agents' information and the address lists normally demand to record information of the Agents often communicating and recently communicated, which reduces the Agents' burden, so as to reduce requirements of individual Agent in the virtual team and to facilitate cooperative probability of the team.

This paper introduces an Agent relation network model to carry out quantitative calculation for the trust and relation and supplies a constitution and assessment system for the trust model of the virtual team. Reasonable constitution and quantitative calculation in this system provide the managers with effective tools. The next research is to constitute an emulational system and an information management platform on the basis to further optimize the model parameters.

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