Assessment of P2P Trust Model Based on Fuzzy Comprehensive Evaluation

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***Abstract*—The trust value based on fuzzy comprehensive evaluation fluctuates remarkably. Aiming at this problem, this paper establishes membership function of trusted set, according to the trusted level in P2P trust model based on fuzzy comprehensive evaluation. The simulation results and analysis show that the membership function of trusted set can validate whether the trust evaluation value is sufficiently close to the trusted level.**

***Index Terms*—fuzzy comprehensive evaluation, trusted set, membership function, trusted level**

I. INTRODUCTION

In recent years, P2P technology is widely applied in e-commerce, resource sharing and other domains. Many scholars place themselves in the research on all aspects of P2P technology [1-5,15-16]. Some scholars [6-7] specially make greater progress on the application of P2P technology. But, for the openness and anonymity of P2P networks, it has various security risks. So the research on P2P trust model becomes one of the hot topics in the P2P networks security. Trust itself is of great subjectivity, uncertainty and ambiguity. Fuzzy comprehensive evaluation is a very effective method to solve the problem.

The literature [8] and [9] apply fuzzy comprehensive evaluation to research in engineering management. At present, fuzzy theory is used to evaluate trust value of peers in P2P networks, for embodying the essence of trust [10-14]. But quantizing the peer's trust value based on fuzzy theory makes peer's final trust evaluation result fluctuant. Aiming at this phenomenon, on the basis of fuzzy set, this paper establishes membership function of trusted set according to the trusted level in the P2P trust model. Through the membership function of trusted set, we can assess whether the trusted degree of peers is sufficiently close to the trusted level.

Section II describes some basic knowledge, which is related to assessment of P2P trust model based on fuzzy comprehensive evaluation. We presents that how to assess the P2P trust model based on fuzzy comprehensive evaluation in section III. Section IV introduces the simulation and analysis. The last section is the conclusions.

II. RELATED KNOWLEDGE

A. Direct trust and Recommendation Trust

In P2P networks, the trust between peer and objective peer usually includes direct trust and recommendation trust. Direct trust is obtained by the direct experience of peer itself to objective peer, as shown in Fig. 1, where *x* is a peer, *z* is an objective peer. Recommendation trust is the direct trust of the trusted peers to the objective peer *z*, as shown in Fig. 2, where $y_i (i = 1, 2, ..., n)$ is a trusted peer. The trusted peers are also called recommendatory peers.

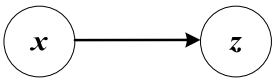

Figure I. Direct trust

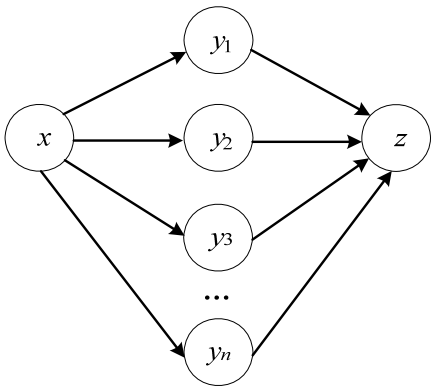

Figure II. Recommendation trust

B. Trust Description based on Fuzzy Comprehensive Evaluation

In order to describe P2P trust model based on fuzzy comprehensive evaluation better, we introduce the following definitions.

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Definition 1: In P2P networks, the various factors affect the overall trust performance of an objective peer. Suppose the factors set of the objective peer is $E=(E_1,E_2,.....E_n)$, and $\overline{A}=(a_1,a_2,.....a_n)$ is weight of each factor, where $\sum_{i=1}^{n}a_i=1$. a_i can be gained according to the situation of transaction context and behavior of the objective peer.

Definition 2: Suppose the granularity of trusted level is m. Through fuzzy statistics of the recommendation trust to all recommendatory pees, we can get the corresponding fuzzy matrix of the recommendation trust $\overline{R}$, and $\overline{R}=(r_{ij})_{n\times m}$.

Definition 3: The fuzzy comprehensive evaluation $\overline{B}=\overline{A}\circ\overline{R}$. $\overline{B}=(b_1,b_2,.....b_m)$ is the original recommendation trust vector of objective peer, where $b_j=\vee_{i=1}^{n}(a_i\wedge r_{ij})$. Equation (1) gives the new quantification RT of recommendation trust vector, where $\overline{Q}=(q_1,q_2,.....q_m)$ and $\overline{Q}$ is the quantization value of the trusted level.

$$RT=\overline{Q}\times\overline{B}=\sum_{i=1}^{m}q_ib_i \tag{1}$$

Definition 4: Assume the granularity of trusted level is 4, as shown in Table Ⅰ. According to Table Ⅰ, we can get that $\overline{Q}=(0.875,0.625,0.375,0.125)$.

TABLE I.

THE OBJECTIVE PEER'S TRUSTED LEVEL AND QUANTITATIVE INDICATORS

T	Trusted Level	Language Description	The interval of quantization value
t_1	4	Full trust	(0.75, 1]
t_2	3	General trust	(0.5, 0.75]
t_3	2	Partial distrust	(0.25, 0.5]
t_4	1	Distrust	[0, 0.25]

Definition 5: $T=\lambda DT+(1-\lambda)RT$, where $\lambda\in[0,1]$, T is the final trust value of objective peer, and DT is the direct trust value. In this paper, we suppose $\lambda=0.5$.

III. ASSESSMENT OF P2P TRUST MODEL BASED ON FUZZY COMPREHENSIVE EVALUATION

On the basis of fuzzy set, the paper establishes membership function of trusted set to validate whether the trust evaluation result is sufficiently close to trusted level and maximum membership principle.

A. Trust Evaluation

According to definition 4, divide trusted level of objective peer into four different trusted sets, which are t_1, t_2, t_3 and t_4. They are respectively full trust set, general trust set, partial distrust set and distrust set. The membership functions of trusted set are as follows:

$$t_1(T)=\begin{cases}0 & 0<T\le 0.5\\ 2(\dfrac{T-0.5}{0.5})^2 & 0.5<T\le 0.75\\ 1-2(\dfrac{1-T}{0.5})^2 & 0.75<T\le 1\end{cases} \tag{2}$$

$$t_2(T)=\begin{cases}0 & 0<T\le 0.25\\ 2(\dfrac{T-0.25}{0.5})^2 & 0.25<T\le 0.5\\ 1-2(\dfrac{0.75-T}{0.5})^2 & 0.5<T\le 0.75\\ 2(\dfrac{0.75-T}{0.5})^2 & 0.75<T\le 1\end{cases} \tag{3}$$

$$t_3(T)=\begin{cases}2(\dfrac{T-0.25}{0.5})^2 & 0<T\le 0.25\\ 1-2(\dfrac{T-0.25}{0.5})^2 & 0.25<T\le 0.5\\ 2(\dfrac{0.75-T}{0.5})^2 & 0.5<T\le 0.75\\ 0 & 0.75<T\le 1\end{cases} \tag{4}$$

$$t_4(T)=\begin{cases}1-2(\dfrac{T}{0.5})^2 & 0<T\le 0.25\\ 2(\dfrac{0.5-T}{0.5})^2 & 0.25<T\le 0.5\\ 0 & 0.5<T\le 1\end{cases} \tag{5}$$

B. P2P Trust Model Evaluation

According to the above relevant description, the assessment steps of the P2P trust model based on fuzzy comprehensive evaluation are as follows:

Step 1. According to the situation of transaction context and behavior character of objective peer *z*, determine the factors set E and the corresponding weight of the factors set $\overline{A}$.

Step 2. Record direct trust vector and get the direct trust value DT. If having no any experience with objective peer *z*, the direct trust value DT is 0.

Step 3. Based on the objective peer's trusted level, collect all trusted recommendatory pees, and get the recommendation trust vector of *z*.

After fuzzy statistics, we get the corresponding fuzzy matrix $\overline{R}$.

Step 4. According to definition 3, obtain the recommendation trust vector $\overline{B}$ and do quantification.

Step 5. According to definition 5, get the objective peer's the final trust value T, and referring to Table Ⅰ, judge the trusted level of the objective peer *z*.

Step 6. By the membership function of trusted set, we can judge whether T is sufficiently close to primary trusted level. If they are consistent, the assessment is end. Otherwise, adjust the trusted level, establish membership function of trusted set again, and do reassessment.

IV. Simulation and Analysis

In P2P networks, before a peer uses the objective peer *z*'s file sharing service, the peer need to do trust evaluation to the objective peer *z*. Suppose the objective peer *z*'s factors set $E=(E_1,E_2,E_3,E_4,E_5)$, which are respectively bandwidth utilization vector, cooperative computing vector, the number of available resources vector, online time vector and stability vector. According to the situation of transaction context and behavior character of objective peer *z*, set the weight $\overline{A}=(0.1,0.1,0.3,0.15,0.35)$. The quantification value of *z*'s direct trust vector is 0.7. By step 3, get the corresponding fuzzy matrix $\overline{R}$ of the recommendation trust:

$$\overline{R}=\begin{pmatrix} 0.2 & 0.5 & 0.3 & 0 \\ 0.1 & 0.3 & 0.5 & 0.1 \\ 0 & 0.4 & 0.5 & 0.1 \\ 0 & 0.1 & 0.6 & 0.3 \\ 0.5 & 0.3 & 0.2 & 0 \end{pmatrix} \tag{6}$$

After fuzzy comprehensive evaluation, get the recommendation trust vector $\overline{B}=(0.35,0.3,0.3,0.15)$. By definition 4 and 5, get the final trust value T, which is equal to 0.66. Referring to Table Ⅰ, T belongs to general trust. By step 6, the results are shown in Table Ⅱ.

TABLE II.

Membership Degree of Trusted Value of the Objective Peer

Trusted set	Membership degree
t_1	0.21
t_2	0.94
t_3	0.15
t_4	0

From Table Ⅱ, we can see that the objective peer *z* belongs to the general trust of trusted sets. The membership degree is 0.94. And according to maximum membership principle, the objective peer *z* is general trust assuredly.

TABLE III.

Evaluation Result

Objective peer	Trusted value	Trusted level	Membership degree of trusted set			
			t_1	t_2	t_3	t_4
Z_1	0.56	General trust	0.03	0.71	0.29	0
Z_2	0.63	General trust	0.14	0.88	0.12	0
Z_3	0.78	Full trust	0.61	0.007	0	0
Z_4	0.40	Partial distrust	0	0.18	0.82	0.08
Z_5	0.36	Partial distrust	0	0.10	0.90	0.16
Z_6	0.80	Full trust	0.68	0.02	0	0
Z_7	0.12	Distrust	0	0	0.14	0.89
Z_8	0.62	General trust	0.12	0.86	0.14	0
Z_9	0.37	Partial distrust	0	0.12	0.88	0.14
Z_{10}	0.08	Distrust	0	0	0.23	0.95

In order to analyze the accuracy of membership function of trusted set on validating the trust evaluation result of P2P trust model, we selects 1000 objective peers in the model, and judge whether the result is consistent.

The results of ten objective peers are shown in Table Ⅲ. After the computing and analysis, the membership function of trusted set can validate the trust evaluation result of the P2P trust model, and the accuracy is about 99%.

V. Conclusions

On the basis of fuzzy set, establish membership function of trusted set according to the trusted level in the P2P trust model and maximum membership principle. Through the membership function of trusted set, validate whether the trust evaluation result is sufficiently close to trusted level. The method is strong applicability in the event that the granularity of trusted level is great. Whether or not to be applicability for

other P2P trust model and how to improve the method to make it easy to operate will be our future works.

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