A Recommendation Trust Method Based on Fuzzy Clustering in P2P Networks

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***Abstract*—In this paper, we apply the thought of maximal tree to propose a peer classification method. It's based on fuzzy clustering. The method classifies effectively the recommendation peers according to their trusted level. Finally, the experiment results show that if you choose the recommendation peers with higher trusted level, their recommendation result will be more truthful and reliable. So our method can effectively avoid false recommendation, and enhance the accuracy of trust evaluation in P2P networks.**

***Index Terms*—fuzzy clustering, thought of maximum tree, recommendation trust, recommendation peer**

I. INTRODUCTION

In recent years, the openness and anonymity of P2P networks make it be widely used in e-commerce domains. But in P2P networks, how to evaluate accurately the peer's trust is a key point of P2P network security research. At present, in the case of that source peer and destination peer don't have too much interactive experience, so we can only depend on the recommendation trust. But the P2P network's features make the network exist a lot of group fraud and false recommendation behaviors. How to distinguish effectively the recommendation peers, and enhance the reliability of the recommendation are especially important in the trust evaluation of destination peers.

Some scholars [3-9] apply fuzzy theory to the trust evaluation of P2P peers, which provides us with a very valuable mentality. Zhang [11] applies fuzzy clustering to classify recommended peers. But if the number of recommendation peers is large, workload will increase exponentially. In this paper, we propose a peer classification method, which applies thought of maximum tree [15] based on fuzzy clustering. It not only can classify effectively the recommendation peers according to its trusted level, but also can reduce computational complexity.

Section Ⅱ describes recommendation trust and its relevant definition, and proposes the peer classification method based on the thought of maximal tree. There are two experiments in section Ⅲ. The last section is the conclusion.

II. RECOMENDATION TRUST BASED ON FUZZY CLUSTERING

A. Direct Trust and Recommendation Trust

In P2P networks, we do trust evaluation on destination peers, usually according to comprehensive assessment of direct trust and recommendation trust. Direct trust is obtained according to the experience and observation of source peer with destination peer, which is appraised the destination peer's trust degree. Recommendation trust is some peers which have much experience with destination peers. The accumulated experience and observation of these peers with destination peer are used to do trust evaluation on destination goal peer. And these peers are called recommendation peers.

In P2P networks with a large scale and a large number of peers, the possibility of repeated interaction between peers is small or time spacing between two interactions is too long, so recommendation trust is particularly important in the trust evaluation of destination peer.

B. Relevant Definition of Recommendation Trust

In this paper, we define the relevant vector of recommendation trust to describe recommendation trust more clearly.

Suppose the domain $O=\{y_1, y_2, \dots, y_n\}$ is the recommendation peer set to be classified. Every recommendation peer has m attributes. $(y_{i1}, y_{i2}, \dots, y_{im})$ is the attribute set of recommendation peer y_i. The value of attribute vector and the number of attribute vector should be decided by the actual transaction context.

The similarity r_{ij} between recommendation peer y_i and y_j is the absolute distance of their attribute set, which is denoted by (1).

$$r_{ij} = \begin{cases} 1 & i = j \\ 1 - \alpha \sum_{k=1}^{m} \left| y_{ik} - y_{jk} \right| & i \neq j \end{cases} \quad (1)$$

In (1), α (>0) is constant. According to the actual transaction context, the similarity $r_{ij} \in [0,1]$.

$Q = (q_1, q_2, ..., q_m)$ is the attribute weight set of recommendation peers, which will be endowed different weight according to characteristic of transaction context. $q_i \in [0,1]$ and $\sum_{i=1}^{m} q_i = 1$. According to the above description, recommendation peer's trusted degree will be

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quantified by (2), where t_i is the trusted value of the recommendation peer y_i.

$$t_i = \sum_{k=1}^{m} q_k y_{ik} \tag{2}$$

Suppose that the recommendation peers are divided into c class groups, and the x^{th} class group has h_c recommendation peers.

In (3), $\overline{t_x}$ is the trusted value of the x^{th} class group, where x=1, 2, … , n.

$$\overline{t_x} = \frac{\sum_{k=1}^{h_c} t_k}{h_c} \tag{3}$$

The final trust value of the source peer z to the destination peer x:

$$T_{zx} = \lambda LT_{zx} + (1-\lambda)VT_{zx} \tag{4}$$

LT_{zx} is the direct trust of the source peer z to the destination peer x. VT_{zx} is recommendation trust of the source peer z to the destination peer x, which is calculated by (5). λ is the weight, and $\lambda \in [0,1]$.

$$VT_{zx} = \frac{\sum_{i=1}^{n} LT_{y_i} \times w_{y_i}}{\sum_{i=1}^{n} w_{y_i}} \tag{5}$$

In (5), LT_{yi} is trust evaluation value of the recommendation peer y_i to the destination peer x. w_{y_i} ($\in (0,1)$) is fixed according to the recommendation path of the recommendation peer y_i and the time spacing of interaction between the recommendation peer y_i and the destination peer x.

C. Classification Method of Recommendation Peers Based on Thought of Maximum Tree

We apply the thought of maximum tree of fuzzy clustering knowledge to classify dynamically recommendation peers in P2P networks. According to the relevant description of section *A*, the classification process is as follows:

Step 1: All recommendation peers to be classified act as vertex.

Step 2: If $r_{ij} \neq 0$, the recommendation peer y_i and y_j can be connected with one side.

Step 3: Let $r_{ij}(1 \le i, j \le n)$ in descending order and ranked as $c_1 > c_2 > ... > c_l$, where $c_k(k = 1,...,l)$ is equal to r_{ij}.

Step 4: If the similarity among recommendation peers is c_1, the recommendation peers will be connected, and indicate c_1 at the connecting line, (don't appear intersecting lines). If appearing loop when connecting two peers, they will not be connected.

Step 5: Repeat step4 for $c_2,...,c_k(k \le l)$ one by one until all the recommendation peers be connected.

Step 6: According to the actual transaction context, we set $\beta \in [0,1]$. If the degree of relationship between recommendation peers is less than β, the connected sides of the recommendation peers will be taken off. The remaining peers connected each other, which are bracketed under the level of β, meet the requirement in order to obtain the classification result.

Step 7: According to definition 3 and 4, calculate the various class groups of recommendation peers, which are classified. At last, we can get trusted level of the various class groups of the recommendation peers reference to recommendation peer's trusted level and interval of trusted degree.

III. EXPERIMENT AND ANALYSIS

A. Experiment I

In P2P networks, assume that we obtain recommendation trust value of the recommendation peer set $(y_1, y_2, ..., y_5)$ to the destination peer x. In order to guarantee the reliability of the recommendation trust value, we classify the recommendation peer set $(y_1, y_2, ..., y_5)$ according to the method we propose. In the interactive environment, we mainly consider that the reliability of the recommendation peers, resources quantity provided, the historical recommendation creditworthiness, data-handling capacity. After analyzing various attributes of the recommendation peers, the attribute matrix of the recommendation peers is denoted by (6).

$$S_{5\times 4} = \begin{bmatrix} 5 & 5 & 3 & 2 \\ 2 & 4 & 5 & 1 \\ 5 & 5 & 2 & 3 \\ 2 & 3 & 4 & 5 \\ 1 & 5 & 3 & 1 \end{bmatrix} \tag{6}$$

According to absolute distance, we calculate similarity between recommendation peers, and form the fuzzy matrix $\overline{R}$, as shown in (7).

$$\overline{R} = \begin{bmatrix} 1 & 0.3 & 0.8 & 0.1 & 0.5 \\ 0.3 & 1 & 0.1 & 0.4 & 0.6 \\ 0.8 & 0.1 & 1 & 0.1 & 0.3 \\ 0.1 & 0.4 & 0.1 & 1 & 0.2 \\ 0.5 & 0.6 & 0.3 & 0.2 & 1 \end{bmatrix} \tag{7}$$

Based on the method of this paper, similar relationships among recommendation peers will be formed the maximum tree diagram, as shown in Fig. 1.

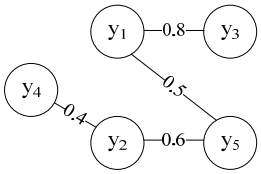

Figure 1. Relationships between recommendation peers

We set $0.5 < \beta \le 0.6$. The recommendation peers will be classified three class groups, which is described in Fig. 2.

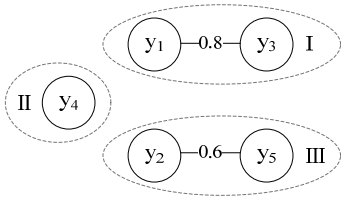

Figure 2. Classification of recommendation peers

There are group I $\{y_1, y_3\}$, group II $\{y_4\}$ and group III $\{y_2, y_5\}$. Other relevant parameters are shown in Table I. Here, we set the attribute weight set of the recommendation peers $Q=(0.3,0.3,0.1,0.3)$. We evaluate the trusted degree of the three class groups of the recommendation peers. The results are $\overline{t_1} = 4$, $\overline{t_2} = 3.4$ and $\overline{t_3} = 2.5$. Referring to Table I, the trusted level of three class groups of the recommendation peers are respectively "Trust", "Partial trust" and "Mistrust". According to the purpose and circumstance of the interaction, we choose different trust level of the recommendation peers, and then do recommendation trust to the destination peer x.

TABLE I.

RECOMMENDATION PEER'S TRUSTED LEVEL AND INTERVAL OF TRUSTED DEGREE

T	Trusted level	Meaning	Interval of trusted degree
T_1	3	Trust	[4,5)
T_2	2	Partial Trust	[3,4)
T_3	1	Mistrust	[2,3)

B. Experiment II

The recommendation peers are classified by the method we propose, in order to confirm that the recommendation peers selected are in higher trust level, and the recommendation value is more reliable. In order to mostly research on recommendation trust, we choose the condition that source peer and destination peer don't have interactive experience (direct trust is equal to zero). Meanwhile, for the computation convenience, we ignore the recommendation path and the time spacing of interaction between the recommendation peers and the destination goal peer. We select separately 100 recommendation peers from "Trust" class group, "Partial trust" class group, and "Mistrust" class group. In the identical transaction context, the recommendation peers separately do trust evaluation on the destination peers ($x_1, x_2, ..., x_6$). And for contrasting better the recommendation value of every class group of recommendation peers with actual trust value of the destination peer, the process is achieved through the VC + +. The experimental result is shown in Fig. 3.

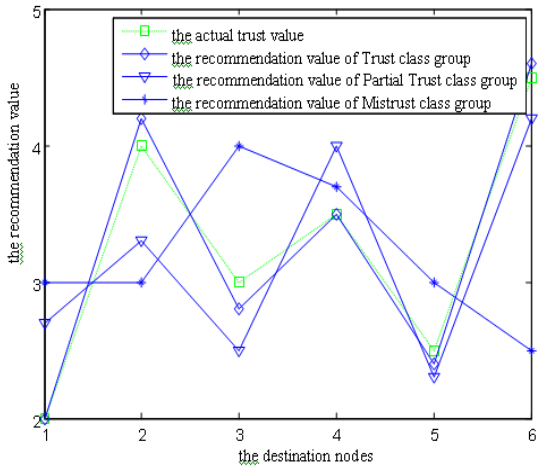

Figure 3. Contrast figure of the recommendation trust value and the actual trust value

From Fig. 3, we can see that the recommendation values of "Trust" class group of the recommendation peers are closer to the actual trust value of the destination peers. However, there is a difference between recommendation values of "Distrust" class group of recommendation peers and the actual trust value. So, when we do trust evaluation to the destination peer, we can try our best to select the recommendation peers, which are in higher trust level, according to the recommendation peers classification.

IV CONCLUSIONS

With the popularity of the P2P network applications, the network begins to appear more and more groups fraud and false recommendation such behavior .In this paper, aiming at this phenomenon, we propose a peer classification method based on the thought of maximal tree. It can effectively classify recommendation peers according to their trusted level, improve reliability of recommendation trust, and also enhance the accuracy of trust evaluation of P2P network peers at the same time. But how to simplify this method, and make it easy to operate are our future works.

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