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Abstract: This paper establishes a trust model based on fuzzy set. It's a method based on subject uncertain theory. Adopting the fuzzy comprehensive evaluation, it computes direct trust value more diversiform and flexible. In the calculation of indirect recommended trust value it brings in the similarity coefficient that can find the peers who can provide more valuable information.

Keywords: Peer-to-Peer, trust model, fuzzy set, similarity

1. INTRODUCTION

Peer-to-peer environments significantly increased the utilization of information, bandwidth and resource in the Internet. P2P systems have become mainstream applications for file sharing and other interests. But it does not require a central authority to mediate such exchanges, so it needs to address some of its own unique security problems [1, 2]. Because of the dynamic distributed characteristics of the peers, any one of peer nodes is likely to download documents from other peer nodes. However, the description of document contents provided by the documents owner is it true? Is it whole? Is it has harmful information? All of these questions are not directly guaranteed in the P2P system. The safety of its system is very important to the huge group of users. It is necessary to establish a comprehensive credit evaluation system to constrain the peer nodes, so that can maximum ensure the reliability and authenticity of the contents of the sharing documents.

According to the different mathematical methods, the research of P2P trust model can be divided into two groups: trust model based on accurate theory and based on subjective theory. Bayes [3] trust model and PeerTrust [4] trust model are typical researches based on accurate theory. But these models ignore the people's subjective views on the trust, so the accuracy of calculation of trust still needs to be enhanced.

In the subjective theory, often using the evidence space and the opinion space concept [5] to describe and measure relationship of trust, and providing a set of subjective logic operator for the trust derivation and combined. But these modes can not effectively eliminate the impact of malicious recommended. To address this problem the paper proposes a subjective trust model based on fuzzy sets.

2. TRUST AND TRUST TYPES

Trust is a kind of credible value which used to estimate the ability that the action taken by one entity to another. This reliable confidence is a dynamic value which is mostly determined by its past behavior [6].

According to the different trust acquisition methods, trust can be divided into two groups: direct trust and indirect recommended trust.

First, direct trust is a subjective expectations of the target entity's future behavior based on the directly interaction experience between the entities in a particular environment and specific time.

Second, Indirect recommended trust is a integrated expectations about the target entities which are recommended by the intermediate entities. When a entity make the trust decision, if there is no direct interaction or less interactive experience between the entities, often use other peers' recommend trust to make choice.

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3. THE FUZZY DESCRIPTION OF TRUST

Definition 1. Let U is electronic commerce problem domain in P2P network, $u_1, u_2, \Lambda\ u_n$ are nodes in the P2P network.

Definition 2. Let fuzzy subset A is a mapping on domain U interval [0,1], it can be expressed as follows: μ_A: $U \to [0,1], u\ \alpha\ \ \mu_A(u) \in [0,1]$

$\forall u \in U$, mapping $\mu_A(u)$ is membership function of subset A.

Definition 3. The whole fuzzy sets on domain U compose a set called U's fuzzy power set. Recorded as follows: $\Re(U) = \{A \mid \mu_A : U \to [0,1]\}$

The trust level of the node is a vague concept, people usually use linguistic variables to describe the level of trust. The model uses five fuzzy sets $A_i \in \Re(U)$ (i=1,2,…5) to define trust set, which uses discrete calibration {1,2,…5} to describe the trust level of nodes. And using natural language to name A_i, let meaning of fuzzy subset more intuitive. The meanings of A_i are as follows:

A_1—— 'no confidence' subset;

A_2—— 'a little confidence' subset;

A_3—— 'general confidence' subset;

A_4—— 'trust' subset;

A_5—— 'very confidence' subset;

In practice, the membership degree of fuzzy set on nodes trust is not a simple 0 or 1, it can not judge out the trust of nodes belong to which fuzzy subset, so it can use the vectors which are constituted by various membership of fuzzy subsets to describe the trust of the nodes. Therefore, the trust value of u_2 rated by u_1 can be expressed as $T = (\nu_1, \nu_2\ \Lambda\ \nu_n)$, and ν_j means u_2's membership degree to A_j. Generally speaking, the nodes which have higher confidence level with the larger membership degree are more credible, and we can also use weighted average method to calculate a trust value arrive at [0, 1].

4. A TRUST MODEL BASED ON FUZZY SET

This trust model based on subjective fuzzy set is composed of two parts: one part is the direct trust value of target node rated by source node, and the other part is the indirect recommended trust value of target node rated by other nodes.

Establish the Direct Trust

Four elements are needed in the fuzzy comprehensive evaluation on trust:

① Evaluation factor set $\mathrm{E} = \{e_1, e_2, \Lambda\ e_n\}$;

Factor set includes all the factors in the process of evaluating trust, such as: quality of transactions, transaction size, etc. In the model, all nodes in the P2P use the evaluation factor set are same.

② Evaluation set $V = \{v_1, v_2, \Lambda\ v_n\}$;

Evaluation set V describes the level of trust, including no-confidence, a little confidence, general confidence, trust, very confidence, is equal to the above five fuzzy subsets.

③ Evaluation Matrix $R = (r_{ij})_{n\times l}$;

Each element of the factor set should do single factor judgment, after the judgment, each element has a corresponding evaluation vector, finally all judgment vectors will compose a matrix, namely single factor evaluation matrix. Actually, it is fuzzy relationship mapping from U to V, in which r_{ij} refers to the possibility of the judgment of the element i to evaluation j.In the single factor evaluation matrix, each judgment vector is definite by each element concrete degree of membership function.

④ The distribution of weight vector on each factor $w = \{w_1, w_2, \Lambda\ w_n\}$

The theoretical basis of fuzzy comprehensive evaluation is fuzzy transformation [7], in this model, fuzzy comprehensive evaluation should do the fuzzy transformation as follows:

$$(t_1, t_2, \Lambda\ t_n) = (w_1, w_2, \Lambda\ w_n)\ \mathrm{o}(r_{ij})_{n\times l}$$

After fuzzy comprehensive evaluating, it can get the trust vector T, then use the weighted average method to establish a trust appraisal value t finally, but it is not directly trust value, is only one part of it, the whole direct trust formula is as follows:

$$DT_i = \alpha v_i + \beta N + \gamma P_i \qquad (1)$$

Among the formula (1), v_i means the total trust of target node rated by source node before transaction i, it can be expressed as follows:

$$v_i = \sum_{\mathrm{k}=1}^{i-1} t_{\mathrm{k}} \qquad (2)$$

Among the formula (1), N is a penalty item, if there is deceit in the transaction or other reasons causes the transaction defeat, and then the node will obtain the penalty. The formula of N is:

$$f(i)\frac{1}{1+e^{-n}}\ [8] \qquad (3)$$

The definition of $f(i)$ is as follows:

$$f(i) = \begin{cases} -1 & \text{transaction } i \text{ defeat because of deceit} \\ 0 & \text{transaction } i \text{ success} \end{cases}$$

Where $\frac{1}{1+e^{-n}}$ is accelerating factor, n is times of failures. This accelerating factor let the trust value rapid decline when exist failures, and because this factor is increases along with n increases gradually, so it can prevent a phenomenon which receive heavy punishment because 1-2 times unintentional deception.

Among the formula (1), $\mathrm{P_i}$ is a reward factor, the node which often gives recommendation and has high accuracy will receive the reward. And $\mathrm{P_i}$ is the contribution of target node to the whole P2P electronic transaction network system before transaction i. $\mathrm{P_i}$ can be expressed as follows:

$$\mathrm{P}_i = \sum_{k=1}^{m} C_i \cdot m \qquad (4)$$

Where C_i is the accuracy rate of each recommendation, m is the recommendation times which target node provides to source node.

Among the formula (1), α, β, γ are weights ($\alpha + \beta + \gamma = 1$), using in balance the proportion of trust evaluation and reward in the trust calculation.

Establish the Indirect Recommended Trust

In this model, using weighted average approach to integrated trusts which are recommended by each recommendation node. Following like:

$$R = \sum_{i=1}^{n} \frac{w_i \cdot rt_i}{k} \qquad (5)$$

Where R is obtained indirect trust value through calculation, namely trust value, rt_i stands for recommended trust value from node i, w_i means the credibility value of node i, representing the recommended adoption level of the nodes, n is the number of nodes which accept the recommendation, and k is the total credibility value this time. In the calculation of indirect trust, each node maintains a recommended trust table, in which save the recommended trust of other nodes. This model assumes all nodes in the network use the same evaluation set, that is means using the same trust rank division in the trust appraisal.

In this model recommended value judgment based on trust from direct interactive experience with source node, and its calculation includes three parts: the accuracy of recommendation, the similarity between recommendation nodes and the source node, and times of successful transaction between recommended nodes and source node. The formula is as follows:

$$w_i = \frac{I(i)}{\max(I(i))}(\alpha S + \beta C), \alpha + \beta = 1 \qquad (6)$$

Where w_i is the recommendation credibility value of node i , S is similarity to source node, C is the

accuracy of recommendation, $I(i)$ means the successful times of transaction between source node and node i, $\max(I(i))$ means the maximum successful times of transaction between source node and the other nodes. And α, β are weights, means the proportion of similarity and accuracy in recommended trust calculation.

Among the formula (6), it uses Minkowski distance [9] $d_m(T_{\text{local node}}, T_{\text{recommended node}})$ method to calculate the similarity of the fuzzy vector. Calculation formula is as follows:

$$d_m(A,B) = \left[\left|\mu_A(x_i) - \mu_B(x_i)\right|^q\right]^{\frac{1}{q}} \qquad (7)$$

Deciding The Fuzzy Set

It can be seen that, in this model, the trust value is determined by two aspects: direct trust and indirect recommended trust, the formula can be expressed as:

$$T = \alpha DT + \beta R\ ,\ \ \alpha + \beta = 1 \qquad (8)$$

5. CONCLUSIONS

This paper proposes a trust model based on fuzzy set. It is a subjective uncertainty theory. Adopting the fuzzy comprehensive evaluation in the calculation of direct trust, it not only can inspect the target node in many aspects, but also can adjust weights if necessary, focusing on one or a few selected aspects trust of target node. And in this model, it proposes a newer method of recommended trust, confidence will be divided into recommend similarity and recommended accuracy of two parts, and integrated them using weighted average method, not only to identify the most accurate recommended node , but also to find the most similar view of the node. This method overcomes the existing model which updated recommendation trust only takes a part that has certain one-sidedness shortcomings.

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