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Model of Assessment of Trustworthy User Based on Fuzzy Theory under Cloud Environment

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Abstract: To solve the two problems that users are independent of each other, it does not form indirect trust relationship between user and cloud service providers, and the traditional method of quantitative measures user's granularity so small. This paper introduces model of assessment of trustworthy user based on fuzzy theory. This model divides the range of trustworthy area based on fuzzy theory in mathematical thought in moderate granularity, and introduces the impact factor that is the neighboring access interval, solves the problem of establishing between user and service providers that is indirect trust. Finally, this paper mines the important influence factors through the simulated experiment, proves this model can measure trustworthy user in directly.

Keywords: fuzzy theory, time impact factor, cloud environment, assessment of trustworthy, membership grade.

1. Introduction

Cloud computing is a new computing model formed by the P2P computing, distributed computing and grid computing [1]. The user can accord the need to pay. When user passes the application, he can modify and upload operation in the cloud resources. Cloud computing appears makes the calculation mode completely got rid of the traditional local mainframe computing model, both in computational speed and data sharing or calculation of wear and tear and other aspects have been greatly improved.

With the rapid development of cloud computing technology, the world's major companies have launched a unique cloud computing services. Such as Amazon Elastic Compute Cloud EC2 and S3 simple storage service, IBM Blue Cloud, Google App Engine [2]. But any Internet users can free access to cloud computing system it is the uncertainty and dynamic behavior of users and cloud service providers, so safe and trusted cloud computing services to become a major problem [3]. Cloud computing services security mechanism can be divided into two categories: "hard security " and "soft security". Hard security includes authentication and access control. Soft security includes trust and reputation evaluation and trust mechanisms between users and cloud service providers [4]. The trust of cloud environment research has just started and how to building a trusted bridge between service providers and cloud users has become an urgent need in the cloud service.

Trust model is proposed that can be traced back to the end of the last century, M.Blaze et alis given at the beginning of the trust model [5]. The trust relationship description methods and safety strategies and key security authorization mechanism, and developed PolicyMaker [5] and KeyNote [6], trust mechanism research has begun.

From a sociological point of view, the meaning of trust is an emotion with strong subjective factors between person and person; it has a certain degree of subjectivity and uncertainty. And in a cloud computing

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environment, each user accesses cloud resources pool, they also has strong uncertainty. In fact, quantitative assessment of a user trusted or not is that quantitative analyses the uncertainty and randomness. Ignoring these two properties of the characteristics its own, so quantitative measure user trust or not is not entirely reasonable.

M.Blaze et al definite trust management mechanism at the same time, fuzzy theory is introduced in the concept of mathematical concepts and further defines the indirect trust metric and comprehensive trust metric [5]. So far, a lot of research experts and scholars have done some research in our country and abroad. The existing trust model includes the Beth model was proposed in 1994 [7], and Josang proposed modelwas proposed in 2001 [8]. These models are mainly used in the mathematical theory of probability theory to solve the trust model of the problem. But it is too strict to defining the direct trust degree in the Beth model, the fuzziness of trust itself is considered insufficient; Josang model will be combined the concept of fact space with the lack of space, the model improved the problem that fuzziness of Beth model is insufficient, but it still can not be a correct assessment of trust.

But objectively speaking, Beth model and Josang model play a guiding role; the two models have showed how to use the fuzzy theory in trust evaluation. The fuzzy theory has been widely applied in the research of trust evaluation; the research results obtained quite rich. Ma and Zhao et al proposed the establishment of user behavioral evidence membership to assess the user behavior trust in order to facilitate the realization of user behavior evaluation in the practical trusted network [9]. Liu reviewed the fuzzy trust evaluation model in detail, and proposed a recommendation trust model based on fuzzy evaluation in P2P network, in order to improve the security of the interaction between nodes in P2P networks [10]. Jin et al introduced the fuzzy theory in the operating system integrity of the trust metric and accurate obtained a complete operating system measurement model in order to improve system availability [11]. Sun et al proposed a subjective trust evaluation model, which is intended to solve the subjectivity and uncertainty of trust in the network environment [12].

In a word, the theory of fuzzy trust evaluation method has been widely used in the P2P network and social network. But the result of the application in the cloud environment is not significant, the main reason is that each user is more independent under the cloud computing environment, the user only interact with the cloud, and the interaction between the user and the user is relatively less. The traditional sense of trust degree in the fuzzy theory is not suitable for cloud environment. In view of the above problems, this paper proposes a cloud environment user TrustRank evaluation model based on fuzzy theory, this paper redesigns the calculation model of indirect TrustRank and analyses the important influence factors of direct TrustRank through experimental data in order to solve how to accurately judge whether the user is credible at the present stage in the cloud environment.

2. Related Work

Fuzzy theory was first proposed by American professor L.A.Zadeh of the University of California in 1965, which is mainly applied to the field of mathematics. The basic idea of fuzzy theory is the extension of the uncertainty, in other words, fuzzy theory has unintelligibility. The theory has a strong concept of subjectivity; its characteristic is qualitative division of problem instead of quantitative division. Such as giving a concept of "old man", we can’t set an accurate age limit in the theory. A 60-year-old person can be called the old man; a 57-year-old person can also be called, even a 40-year-old person can be called the old man in a certain degree. This paper applies this theory to the cloud environment user TrustRank evaluation. Before expressing model, this paper will give an important knowledge of the theory, which is the definition of membership function.

Definition 1 Membership function is used to express the fuzziness of a thing in precise mathematical method. Assuming a specific set A, $\mu(x)$, which is described in the continuous numerical interval [0, 1], is its characteristic function. $\mu(x)$ expressed the degree which is object x belonging to set A.

$$\mu(x) = \begin{cases} 1, & x \in A \\ 0 < \mu(x) < 1, & x \text{ is membership of A} \\ 0, & x \notin A \end{cases} \tag{1}$$

There are many membership functions. For example, Gaussian type, bell shaped, sigmoid, Z-type, S-type, the trapezoidal and the triangular membership function. On the basis of these, more membership functions have been derived. Such as a bilateral Gaussian type membership function, difference sigmoid membership degree function, II-type membership function. The membership function of the model in this paper is the improvement based on II-type membership degree function.

3. Model Design

Before introducing the model proposed in this paper, we define several concepts in the model.

Definition 2 The Direct TrustRank is the standard TrustRank. When user access the cloud resource pool, some behaviors of access will be accorded, through the standardized calculation, the TrustRank will be calculated. The Direct TrustRank shows DT.

Definition 3 Indirect TrustRank is called time TrustRank. After the user visit, the General TrustRank of user will be stored in database. When the same user access again, his General TrustRank weighted time factor is his indirect TrustRank. The Indirect TrustRank shows UT.

Definition 4 General TrustRank is weighted sum between Direct TrustRank and Indirect TrustRank. The General TrustRank shows T. The formula is as follows:

$$T = \gamma \times DT + \delta \times UT \tag{2}$$

Among them, T is the General TrustRank, and the weight of the direct and indirect TrustRank should be taken into account when calculating the TrustRank the weight of Direct TrustRank shows γ and the weight of Indirect TrustRank shows δ. $\gamma \in [0,1]$、$\delta \in [0,1]$、$\gamma+\delta=1$.

The model of user TrustRank evaluation is proposed in this paper is the improvement of evaluation model in P2P network, recommendation TrustRank of Indirect TrustRank replaces time TrustRank based on time factor. The procedure of the model evaluation is illustrated in Figure 1.

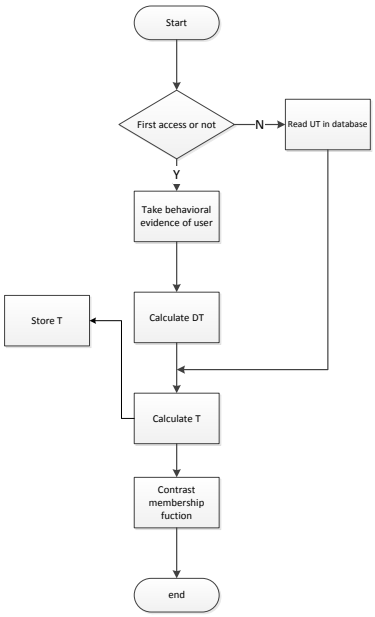

Fig. 1: The procedure of the model evaluation.

As is illustrated in Figure 1, the key factor whether the user is trusted or not lies on the General TrustRank, and the calculation of General TrustRank decided to the results of Direct TrustRank in a great extent. Therefore, the following introduce several influential factors of Direct TrustRank.

3.1. Influence Factor of DT

When a user accesses the cloud, and he did a series of operation such as accessing data, downloading, uploading, user also produced the corresponding behavior. When getting these behaviors, we will be

disposed of normalization. The result of operation directly affect whether the user is trusted or not. According to the different behaviors, the trust management mechanism will also allocate different weights to calculate the corresponding DT. The behavior of DT affect is classified according to the attribute as is illustrated in Figure 2.

In this paper, the influence factors are classified three types according to the attribute as performance attributes, dependability attributes and security attributes. This paper lists the several behavioral evidences according to the user behavior of forensics when the user access cloud server under each attribute. DT will be figured out through these evidences standardized weighing calculation.

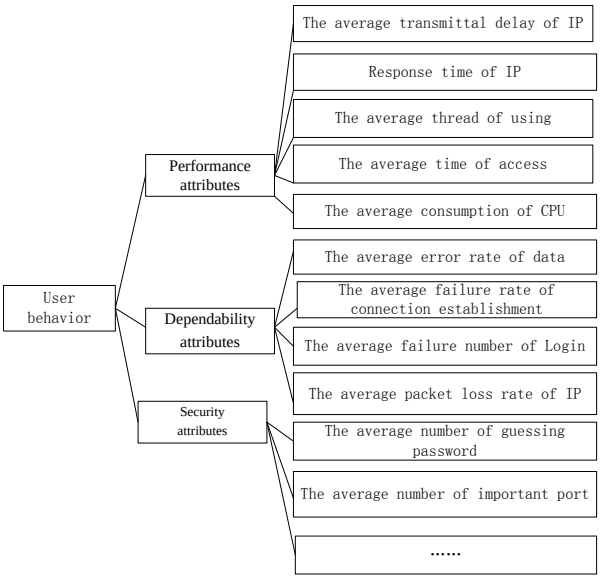

Fig. 2: Influnce factor of DT.

3.2. General TrustRank

According to definition 4 shows, the General TrustRank is weighted sum between Direct TrustRank and Indirect TrustRank. So if we want to calculate General TrustRank, we should calculate Direct TrustRank firstly.

According to definition 2, a behavioral set is U. U={u1,u2,u3,...un}. The influential factor of user behavior is ui. The set of negative factors, such as the high IP packet loss rate, the many numbers of guessing login password, denotes U2. The set of active factors, such as the short IP response time, the fast connection establishment, denoted U1. U1⊆U, U2⊆U, U1∪U2=U. Through standardized calculation of U1 and U2, the results are denoted M(ui) and N(ui). And the Direct TrustRank calculation formula is:

$$DT = \alpha \times M(u_i) - \beta \times N(u_i) \tag{3}$$

Among them, DT is the Direct TrustRank, M(ui) is the result of negative factors, N(ui) is the result of active factors. In this formula 3, α and β are weights. α∈[0,1], β∈[0,1], α+β=1.

According to the definition 3, the Indirect TrustRank formula is:

$$UT = \frac{T'}{t} \tag{4}$$

Among them, UT is the Indirect TrustRank, another name is the time TrustRank, t is the time factor, t∈N*. T ' is the record TrustRank when user accesses the cloud. Every value of T ' is the newest General TrustRank stored in database. The new value of T ' will replace the old one in database.

According to formulas (2) (3) (4), the formula of General TrustRank is:

$$T = \gamma \times DT + \delta \times UT = \gamma \times (\alpha \times M(u_i) - \beta \times N(u_i)) + \delta \times \frac{T'}{t} \tag{5}$$

In this formula 5, γ and δ are weights. γ∈[0,1], δ∈[0,1], γ+δ=1. Assuming initial weights are α=0.5, β=0.5, γ=0.5, δ=0.5. In these weights, α and β do not change. The smaller UT is the bigger γ changes. When

UT=0, γ=1.The δ changes following with the interval of adjacent access. The longer interval is the smaller δ changes. The smaller δ is the bigger γ changes.

3.3. Fuzzy set and Membership Function

As the front of paper said, trust is a fuzzy concept. In order to express the scientific fuzziness of trust, this paper defines four different trusted sets as Table 1 shown.

Table 1: Fuzzy Set Range of TrustRank

Degree	W	B	L	K
Range	0-0.25	0.25-0.5	0.5-0.75	0.75-1

This paper list 4 degrees based on fuzzy theory. The set of completely trustless range is W, the set of trustless range is B; the set of more trustworthy range is L the set of completely trustworthy range is K. As definition 1 known, the General TrustRank substituted in membership degree function. According to the maximum membership principle, the set of trustworthy which user belongs to can be got, the level of trustworthy which user belongs to can be judged. The membership function formula of trustworthy set is improved based on II-type membership function, the formula is shown below:

$$W=\begin{cases}1-2\left(\frac{T}{0.5}\right)^2 & 当\ 0\le T\le 0.25\\ 2\left(\frac{0.5-T}{0.5}\right)^2 & 当\ 0.25\le T\le 0.5\\ 0 & 当\ 0.5\le T\le 1\end{cases}$$

$$B=\begin{cases}0 & 当\ 0\le T\le 0.25\\ 1-2\left(\frac{T-0.25}{0.5}\right)^2 & 当\ 0.25\le T\le 0.5\\ 2\left(\frac{0.75-T}{0.5}\right)^2 & 当\ 0.5\le T\le 0.75\\ 0 & 当\ 0.75\le T\le 1\end{cases}$$

$$L=\begin{cases}0 & 当\ 0\le T\le 0.25\\ 2\left(\frac{T-0.25}{0.5}\right)^2 & 当\ 0.25\le T\le 0.5\\ 1-2\left(\frac{0.75-T}{0.5}\right)^2 & 当\ 0.5\le T\le 0.75\\ 0 & 当\ 0.75\le T\le 1\end{cases}$$

$$K=\begin{cases}0 & 当\ 0\le T\le 0.25\\ 2\left(\frac{T-0.5}{0.5}\right)^2 & 当\ 0.25\le T\le 0.5\\ 1-2\left(\frac{T-1}{0.5}\right)^2 & 当\ 0.5\le T\le 1\end{cases}$$

The membership degree curve of fuzzy function is illustrated in Figure 3. The abscissa is the General TrustRank which gets from formula 5; the ordinate is membership function which gets from formula 1. Considering the safety, when the membership degree of trustworthy level is less than 0.5, the user needs be restricted his access, his service demand should be not responded even the user is forbidden to access cloud.

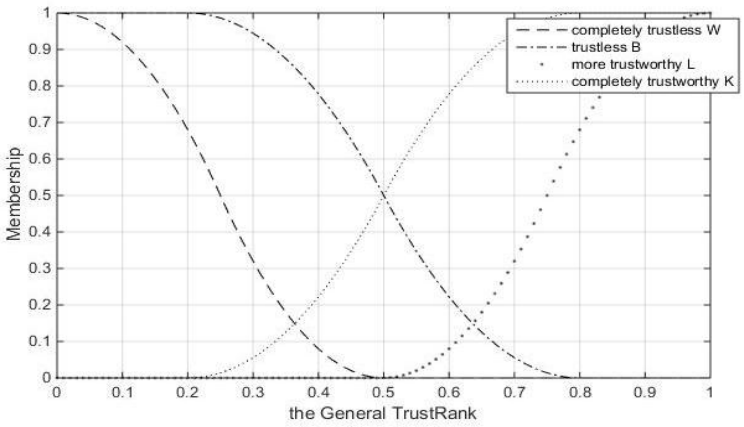

Fig. 3: Membership degree curve of TrustRank.

3.4. How to Work

The working steps of the model are illustrated in Figure 4. The four modules are included in the model.

Monitor Virtual. The role of the monitor is mainly used for collecting the user's the resulting behavioral data when user accesses to the resource pool,.

Change Module. Module is mainly used to receive the data collected by the virtual monitor, and carries out the vector standardization, all the influencing factors will be changed the vector set which can be calculated.

Calculation Module. The main function of this module calculate the vector set which delivered from the Change Module in order to get the final the Genaral TrustRank of user.

Database. The calculated General TrustRank of user are stored in this database from the calculation module. This database recordes 5 sets, such as the user name, the last access time, the new access time, the number of access, the Genaral TrustRank, database record shows as Table 2.

Table 2: Database record

Name	Last time	New time	Number	T
User1	Time1	Time2	Number1	value

The steps of the model: a. user accesses to cloud resources pool; b. the virtual monitor monitors the behavior of user when user accesses to cloud resources pool real time; c. the behavioral evidence delivery change module; d. change module changes behavioral evidence in vector computable set and deliveries calculation module; e. calculation module calculates the user General TrustRank and stores in the database; f. calculation module obtain the record General TrustRank of user from the database. The steps work as Figure 4.

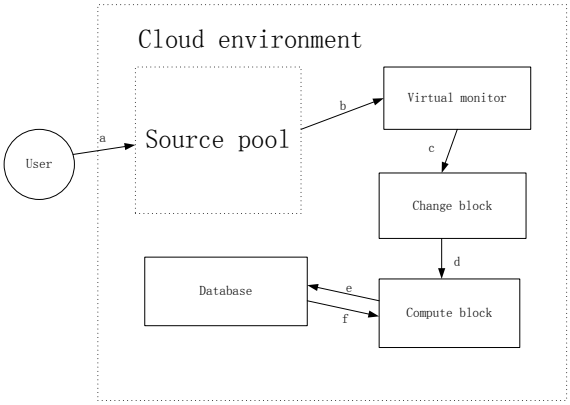

Fig. 4: Work steps.

Module calculates the General TrustRank of user and the results are stored in the database every times. If the database already existed in the user's information, the database would update the information of user, or increased the user's information.

4. Simulation Experiment and Model Performance Analysis

In this paper, the experimental operating environment is Intel(R)Core(TM)i3 2.40GHz CPU, 2GB ROM, 320GB hard disk and Windows7 flagship operating system, software testing environment is the Hadoop 1.0, the experimental data analysis software environment is MATLAB 2014b.

To test two proposed key factors which are the calculation of General TrustRank in this model. The key factors are Direct TrustRank and Indirect TrustRank. The influence degree of influence factor is figured out. The experimental environment randomly selected 100 users. The SAX intrusion detection system detects the 100 users of IP packets in real time, and the number of access important port and other influential factors, records the number of user who has the higher IP packet loss rate and the IP anomaly user, and records the time when user access cloud platform in two adjacent time.

The first step is that analyze the factors of affecting the Direct TrustRank as illustrated in Figure 5. The bigger negative factors N(u) in the Direct TrustRank are, the lower Direct TrustRank will be, when α and β can not change.

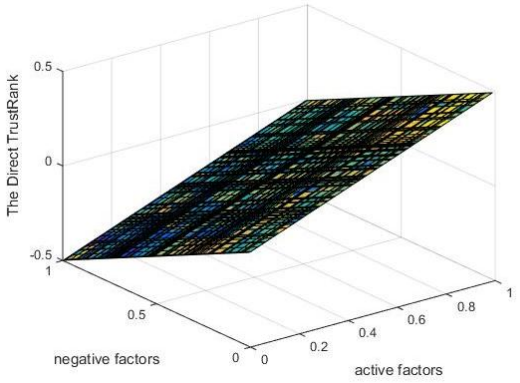

Fig. 5: DT changeable chart.

The secend step is that analyze the factors of affecting the Indirect TrustRank. As formula 4 konwn, the longer access interval is, the lower the Indirect TrustRank is.

The General TrustRank will be calculated by formula 5, and then the membership of TrustRank is as illustrated in Figure 6.

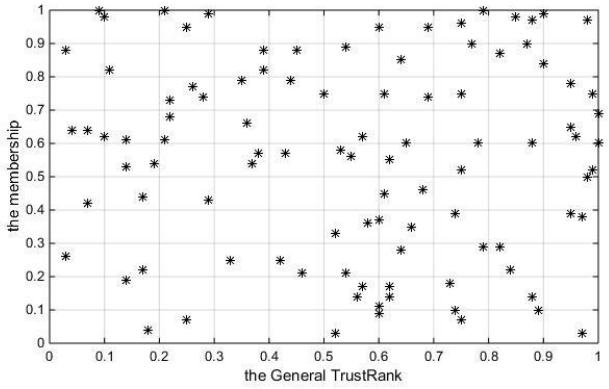

Fig. 6: TrustRank membership.

Figure 6 shows that the 100 users' the General TrustRank and their membership. Though many users' T>0.5, their membership bellows 0.5. They also don't belong to the range of trustworthy. Figure 5 shows the two influential factors of user behavior; they commonly influence the Direct TrustRank.

5. Summary

The problem of trustworthy user has been one of the hot researchable spots in cloud environment. In the traditional mechanism user is classified by quantitative TrustRank division, which makes the divisor granularity is too fine. It makes to define whether the user is trusted inaccurately. This model introduces the fuzzy theory based on mathematical theory; the TrustRank of user is substituted in the membership function through calculating, this model scopes the trustworthy user region clearly, and improves accuracy of the TrustRank division greatly. At the same time this model solves the problem that users are independent in the cloud environment. It does not suit the problem that the trustworthy domain in the traditional fuzzy theory relates to the recommended reliability. The next key step of work solves the problem that the credibility of user cross domain access transmission in and improves the model.

6. References

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