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Research on Trust Management Strategies in Cloud Computing Environment

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Abstract

In order to protect the security of cloud entities and better practice cloud's objectives of providing low-cost and on-demand services, this paper proposes a novel cloud trust transaction framework and also a new trust fuzzy comprehensive evaluation based cloud service discovery algorithm. The new algorithm uses trust multi-dimensional vector to represent the credibility of providers when offer different types of services and applies fuzzy comprehensive evaluation method to classify services. The simulation experiments show that the proposed algorithm ensures relatively high trust accuracy. Besides it has certain advantages in rejecting malicious nodes and improving the transactions' success rate compared to other kindred solutions.

Keywords: Cloud Computing; Trust Realization Framework; Fuzzy Comprehensive Evaluation; Service Discovery

1 Introduction

With the increase of cloud applications, cloud security [1-4] has aroused widespread concern. Trust which was introduced by M. Blaze [5] in 1996 has proved to be an effective security substitute mechanism in distributed systems [6-12]. Xiaoyong Li in his paper [13, 14] designed an adaptive historical evidence window based dynamic trust model for large and distributed systems. A novel reputation based recommender discovery and service selection approach was proposed in paper [15] which aimed at finding highest reputation recommendation source by looking for the credible recommendation group and through the trust iterative operation. Paper [16] introduced a trust feedback based distributed trust model for P2P environment. And Shouxin Wang proposed a cloud model based subjective trust evaluation method to support the subjective trust decision process in paper [17]. Traditional trust solutions have the following problems when used in cloud environment: a) they care little about trust context which is one of the main features of trust. Actually cloud providers usually have their primary business and due to technical or other factors, they perhaps act quite differently when provide different services; b) they tend to choose the most

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credible node under one single factor, but ignore the other factors in the actual transactions; c) they lack the flexible mechanism to satisfy different cloud entities' different QoS requirements. Besides cloud has many unique features compared to traditional environments, new solutions need to be designed for cloud.

This paper proposed a novel cloud transaction model and also a trust fuzzy comprehensive evaluation based service discovery algorithm. The proposed algorithm uses trust multi-dimensional vector to represent the credibility of providers when offer different types of services and applies fuzzy comprehensive evaluation method to classify services. Through the investigation of users' service tendency and set the evaluation weight, it better reflects trust characteristics of context related and satisfies different users' unique QoS requirements. On the basis of cloud services fuzzy comprehensive rating, it proposes a novel cloud service discovery algorithm.

This paper was constructed as follows: part 2 introduces the overall trust management framework and part 3 explains the new cloud service discovery model. Part 4 shows results of the simulation experiments and the last part is conclusion and future work.

2 Trust Based Cloud Transaction Framework

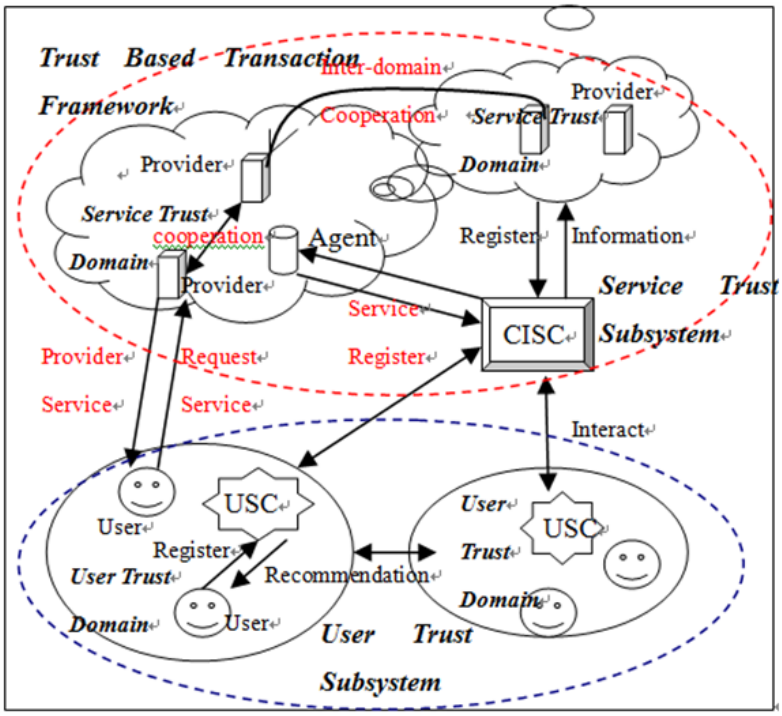

Fig. 1: Trust based cloud transaction framework

In view of cloud's large scale, distributed and resources totally virtualized, the new model divides cloud trust system into two parts: *Service trust subsystem* and *User trust subsystem*. Figure 1 shows the basic transaction framework of the new model. In the service trust subsystem, it sets up a Cloud Information Service Center (CISC) which is the trusted third party and the trust management center for all the providers. Several small or medium providers can alliance into one trust domain. In the user trust subsystem, it sets up a certain number of User Service

Centers (USC). USC is the third party service agency providing B2C services. User trust domain is established on the basis of USC. CISC and USC can exchange data.

We take different trust strategies in carrying out inner domain and cross-domain transactions. Cross-domain transactions exist in transactions between user and provider and cooperation between providers in different domains. The basic process of cross-domain trust decision isWhen A(user) want to trade with B(provider), A first check transaction history with B. If the effective number in the context of the trade context (tc) is larger than the direct trust threshold, then use the direct trust in the local trust table to take trust decision, else broadcast trust recommendation request within A's recommendation set and calculate integrate trust value combined with the direct trust. Since cloud entities registered in the same trust region have the same direct trust root, they are usually more reliable. In order to reduce the cost, trust decision process inner domain is: If A seek transaction partner on its own initiative, it will pick up the one with highest direct trust in the local trust records; if passive trade context, as long as the other party is not within the transaction refusing list, it will agree. After the deal, the direct trust value will be calculated and refreshed. Besides if the partner isn't credible, it will add it into the transaction refusing list and avoid trading with it in the future.

3 Cloud Service Discovery Mechanism

In order to meet the actual needs of cloud users and find safety and reliable services, we proposed a novel trust based cloud service discovery model that can be used in large-scale and completely distributed cross-clouds environment based on the previous research. The following is the detail of our model.

3.1 Trust evaluation model

Definition 1 Trust evaluation unit is referred to the cloud providers in trust evaluation system. It is described as $CP = \{pID, pName, pTrust\}$. Trust is described by trust value. The meaning of each attribute is as follows:

(1) pID represents the unique id of a provider;

(2) $pName$ represents the name of a provider;

(3) $pTrust$ represents the service trust.

Trust is transaction context sensitive. When the same provider provides different type of service, the service quality and credibility perhaps seems quite different. In order to better describe trust degree in providing different services, we use trust multi-dimensional vector to represent $pTrust$. Since in this paper, we only take into account three service types computation service, network transmission service and storage service. So $pTrust$ can be described as $pTrust = \{cpuT, bwT, storeT\}$. Here $cpuT$, bwT and $storeT$ refer to computation trust, network trust and storage trust respectively.

FCE (Fuzzy Comprehensive Evaluation) is an effective method to evaluate the complex things in Fuzzy mathematics. In cloud, services inevitably involve many aspects (in this paper calculation,

transmission and storage are considered). So the trust evaluation of providers also belongs to the problem of comprehensive evaluation. We chose FCE method to evaluate providers and help users to select more credible transaction object on its demand cloud services. The process of trust comprehensive evaluation based on fuzzy comprehensive evaluation is as follows:

(1) Establish the evaluation factors set U.

(2) Set the weight vectors $\underline{A}$. Weight of different factors should be customizable according to users' different service requirement;

(3) Define judgement set V. Here is the provider set V;

(4) Calculate the judgment matrix $\underline{R}$ according to the membership functions;

(5) Calculate comprehensive evaluation results $\underline{B} = \underline{A} \times \underline{R}$.

3.2 Cloud service discovery algorithm

Trust comprehensive evaluation helps cloud users compare providers' behavior and choose the best partner before transaction.

Cloud Service Discovery Algorithm.

```
CServDiscover(pList,serviceType){
    Boolean found=false;
    providerList choseproviders;
    choseproviders=PFuzzyJudge(serviceType,plist);
/*Trust Fuzzy comprehensive evaluate on providers in the list and return the credible provider
list in their comprehensive trust value descending order */
While(!found&&choseproviders.iterator().hasNext()){
    Provider p= (choseproviders) iter.next();
    found=AskForService(p, serviceType);
    /*Send service request to the chosen provider */
}
}
```

Trust Fuzzy Evaluation Algorithm.

```
providerList PFuzzyJudge(serviceType,plist){
    Vector a=setWeightVector(serviceType);
    //set weight vector according to request service type
    Matrix r=setTrustJudgeMatrix(plist);
    /*construct trust judgement matrix according to weight vector */
```

```
List idList=generateJudgeResult(a,r);
/*calculate comprehensive evaluation result basing on the weighted mean method and return the credible providers' id in the trust value descending order */
providerList resultList=Sort(plist,idList);
/*sort plist according to the comprehensive evaluation result and return the sorted list */
}
```

4 Simulation Experiments

This paper designed simulation experiments of cloud transactions to test the performance of new proposed model, domain-based model and behavior feedback model. The experiments set up two evaluation factors: *trust accuracy* and *transaction success rate*. *Trust accuracy* means the ratio of obtaining correct trust judgements through trust mechanism to the total number of trust evaluations. *Transaction success rate* means the ratio of success transactions to the ideal number of transactions.

Cloud computing environment is simulated containing a certain number of cloud providers and users. In the simulation scene, transactions are induced by two factors: user launching type and provider launching type. The simulation system contains several main parts: cloud interaction environment, user generator, task generator, provider generator, resource generator and trust evaluator. Interaction environment realizes the cooperation of different cloud entities. User generator generates cloud users according to the specified number and deploys all the user's parameters including trust and demand service type. Each user randomly joins one trust domain. Task generator randomly generates user tasks and configures tasks' parameters. Provider generator generates providers according to the specified number and deploys each provider's parameters. Resource generator generates resources and randomly completes the deployment of resources. Trust evaluator executes trust fuzzy comprehensive evaluation algorithm and help to make reasonable trust decisions. Malicious nodes are added in the environment. In this paper, there exist two kinds of malicious nodes: simple malicious nodes and role malicious nodes. Simple malicious nodes will not offer services in any cases. Role malicious nodes act more complex. They may be honest when provide their primary business and probably refuse to provide services when they are request not for primary business.

When we restrict the transaction times, figure 2 shows the result of transaction success rate comparison. Figure 3 shows the result of trust accuracy.

From the results, we could see that our model ensures relatively higher trust accuracy and transaction success rate compared to simple behavior feedback model and domain-based model when malicious nodes increase. Since if there only exist simple malicious nodes, cloud systems with effective trust mechanism can capture such nodes after the chaos of the early trading. But if there are also role malicious nodes who behave credibly when requested for primary business and reject providing service when requested not for primary business, it makes the judgements of traditional trust mechanisms somewhat random. But the proposed model uses trust fuzzy comprehensive evaluation method to observe the subtle changes in different components of trust, thus has the ability to classify providers and bind users to the providers in primary business. In this way, it gains better performance than the other trust models.

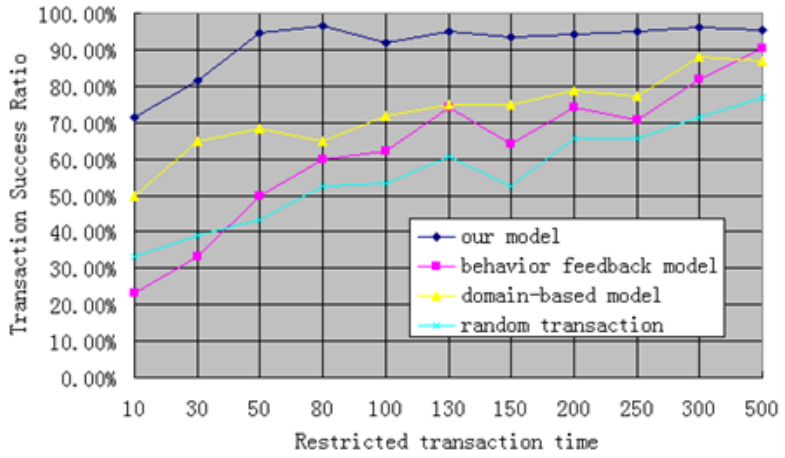

Fig. 2: Result of transaction success rate

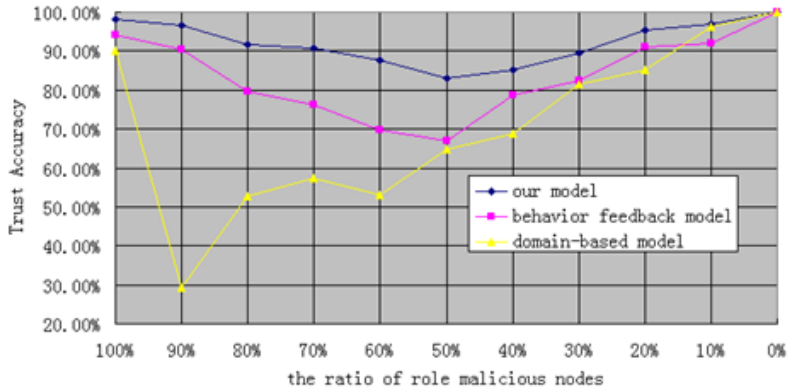

Fig. 3: Result of trust accuracy

5 Conclusion and Future Work

This paper designs a new transaction realization framework for cloud and also it introduces a novel trust based cloud service discovery algorithm. Fuzzy comprehensive evaluation mechanism helps to classify providers according to different service types effectively. Service discovery algorithm based on it has the capability to pick up credible transaction partners quickly. Simulation experiments show the proposed model has relatively high trust accuracy and it can establish trust relationship between customer and provider fast and safe. In future, we will perfect our model and use it in the actual cloud platform and test its performance.

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