A Service Level Agreement for the Resource Transaction Risk based on Cloud Bank Model

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***Abstract*—Cloud computing is a new business computing model. The environment of the resources is very complex. The resources are physically distributed and connected by the network. There are many risks existing in the resource transactions. So how to make sure that the cloud computing platform can avoid these risks during the transactions and assure the quality of services (QoS) provided to the consumers is a very important issue in cloud computing. Service Level Agreement (SLA) is proposed to solve the problems between the customers and service suppliers. Cloud Bank model [1] is a resource management model based on economic principles and aims at solving all the commercial level problems in cloud computing. This paper presents a framework of Service Level Agreement based on the Cloud Bank's liquidity risk [2] predicting model. This SLA can help the Cloud Bank avoid the risks and assure the QoS to the consumers.**

Keywords:Cloud Computing,Cloud Bank Model,Liquidity Risk,Risk Prediction,Service Level Agreement

I. INTRODUCTION

In cloud computing, computing resources are provided as service. The resources are distributed, heterogeneous, dynamic and autonomous, there are many ri sks hidden in the process of resource transactions and the damages caused by these risks directly affect the quality of service (QoS) in cloud computing. Therefore, risk against is the most important part in cloud computing.

Developed from the commercial bank, the Cloud Bank Model [3] is a cloud resource management modeling based on economic principles. In this model, the resources are provided as service by the providers through the network and cloud bank provides services to the consumers. As mentioned above, there are risks hidden in the process of the resource transactions among the providers, cloud bank and consumers, so how to assure the consumers get the services and the resource providers achieve their service promises is the most important issue in Cloud Bank Model. In [2] and [4], there are some researches about risk against in cloud bank, but these two papers just give some strategies.

A service level agreement is a negotiated agreement between two parties wherein one is the consumer and the other is the resource provider. The SLA records a common understanding about services, priorities, responsibilities, guarantees, and warranties. The SLA may specify the levels of availability, serviceability, performance, operation, or other attributes of the service, such as billing. The SLA reports must provide a guarantee that the QoS is being monitored and the Cloud Bank can deal with any accident that may happen [5].

In [5], Cloud Bank Service Level Agreement (CBSLA) is introduced. CBSLA wants to solve all the problems between the customers and the service suppliers in Cloud Bank. But in [5], the CBSLA is just a framework or a template. It is too broad. It didn't present solutions in details.

II. CLOUD BANK MODEL

A. The Introduction of The Cloud Bank Model

The Cloud Bank Model is a resource management modeling based on economic principles. Its function is very similar to commercial banks in deposit and loan business. It offers IaaS. It has four types of resources: CPU, Memory, Disk and bandwidth. The Cloud Bank Model is shown in Figure 1. In this model, the entire cloud computing environment is divided into three roles: Resource Provider (RP), Cloud Bank (CB) and Resource Consumer (RC). In this model, the RP are similar to the depositors in the commercial bank, the RC are similar to the loaners. The cloud bank is similar to the commercial bank, paying the RP and charging to the RC according to some certain interest rates [6].

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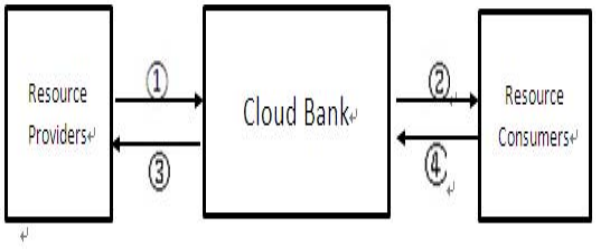

Figure 1Cloud Bank Model

As shown in Figure 1, all the resource transactions of the Cloud Bank can be divided into four parts:

① RP provide their resources to the Cloud Bank. The Cloud Bank gives an initial price of the resources and the saving interest rate, and then signs the saving contract with the RP

② The Cloud Bank accepts the resource-renting applications from the RC and gives the renting interest rate, then signs the renting contract with the RC and offers the resources.

③ When the saving contract expires, the Cloud Bank should return the resources to the RP.

④ When the renting contract expires, the Cloud Bank will take the resources which are offered to the RC back.

B. Liqudity Risk Predicting Model in Cloud Bank

The Cloud Bank's liquidity risk is defined as follows: When the saving contract expires, the RP take their resources back, but these resources may still be rented to the RC. If the resource pool does not have enough resources to substitute those resources which are taken away, the quality of service of the Cloud Bank would inevitably be lower. [2]

The Cloud Bank's liquidity risk may arise when the contract expires. After the RP taking back their resources, the resource pool should have enough resources left to substitute these resources and offer the same level quality of service to the RC. Otherwise the lack of resources would seriously impact on the quality of service and the credit of the Cloud Bank. So if we want to predict the liquidity risk, we should figure out what could cause lack of resources.

As shown in Figure 1, renting resources to the RC reduce the resources in the resource pool. It causes the lack of resources when RP take their resources away. In order to predict the risk, we must monitor the Cloud Bank's loan business.

Here is an assumed situation as follows:

At the time t, the number of the remaining resources in the resource pool is L. There is a renting application. The resource number is A, the renting time is T. During the renting time, the number of RP whose saving contracts would expire is m. For each Resource Provider i, the number of the provided resources is S_i.

Based on this situation, the worst case is that all these m RP choose not to renew the contract. So at the time $(t+T)$, the number of the resources which would be taken away is $\sum_{i=1}^{m} S_i$. If $\mathrm{L}-\mathrm{A} > \sum_{i=1}^{m} S_i$, it means that the resource pool has enough resources to substitute during the term, so the liquidity risk would not happen. The Cloud Bank could agree to this application. If $(\mathrm{L}-\mathrm{A}) < \sum_{i=1}^{m} S_i$, it means the Cloud Bank should not agree to this application. Although this approach can ensure that the liquidity risk would not appear during the term, but it is a static approach, limiting the size of the Cloud Bank's loan business.

In order to improve the approach, three dynamic situations should be added into the situation which is mentioned above:

- During the term, there will be some new resources provided into the Cloud Bank, assume the number is Ad.
- During the term, the number of RP whose saving contracts would expire is m. For each Resource Provider i, the number of the provided resources is S_i. The probability of choosing not to renew the saving contract is P_i.
- During the term, the number of the RC whose renting contracts would expire is n. For each Resource Consumer j, the number of the resources is S_j. The probability of choosing not to renew the renting contract is P_j.

According to these three dynamic situations, at the time $(t+T)$, the number of the resources which should be given back is $\sum_{i=1}^{m}(S_i * P_i)$; the number of the resources in the resource pool is $\mathrm{L}+\mathrm{Ad}-\mathrm{A}+\sum_{j=1}^{n}(S_j * P_j)$. If the inequality

$$\mathrm{L}+\mathrm{Ad}-\mathrm{A}+\sum_{j=1}^{n}(S_j * P_j) > \sum_{i=1}^{m}(S_i * P_i) \qquad (1)$$

is satisfied, it means the resource pool has enough resources to substitute during the term. The liquidity risk would not happen. Then the Cloud Bank could agree to this application. If (1) is not satisfied, it means the Cloud Bank could not agree to this application. (1) is called as the Predicting Inequality. The improved approach can ensure that the liquidity risk would not happen as long as (1) is satisfied.

But if the Resource Consumer of this application chooses to renew the renting contract when the contract expires, the Cloud Bank has no choice but to renew the contract. Because the environment of cloud computing is dynamic. The RC always do not exactly know how much time is needed to finish their tasks. If their tasks are not finished when the contract expires, the Resource Consumer might choose to renew the contract. If the Cloud Bank choose not to renew the contract and take the resources back, it might cause great loss of the RC's benefit. The reputation of the Cloud Bank would be affected badly. As the Cloud Bank choosing to renew the contract, the renting time of this application is extended. If in the extended time, (1) is not satisfied, the liquidity risk may still happen. To predicting the liquidity risk which happens because of the RC renewing the renting contract, the Cloud Bank should monitor all the resources transactions and periodically check that whether the resource pool has enough resources.T' is assumed as the time of one cycle. The number of the RP whose saving contracts would expire is assumed

asm' in one cycle. For each Resource Provider i, the number of the provided resources is S_i'. The probability of the Resource Provider choosing not to renew the saving contract is P_i'.The number of the RC whose renting contracts would expire is n'. For each Resource Consumer j, the number of the resources isS_j'. The probability of the Resource Consumer choosing not to renew the renting contract is P_j'. The number of the new added resources is Ad'. The number of the remaining resources in the resource pool isL'. If the inequality

$$L' + Ad' + \sum_{j=1}^{n'}(S_j' * P_j') > \sum_{i=1}^{m'}(S_i' * P_i') \qquad (2)$$

is satisfied, the liquidity risk may not happen in that cycle. If (2) is not satisfied, the liquidity risk may happen and the Cloud Bank should make the appropriate measures in time to manage the risk. (2) is called as the Monitor Inequality.

C. The Framework of Cloud Bank Service Level Agreement

The CBSLA is designed to capture the service level agreements in a formal way in Cloud Bank environment. The life cycle process of CBSLA is shown in Figure2 which identifies five main processes [5].

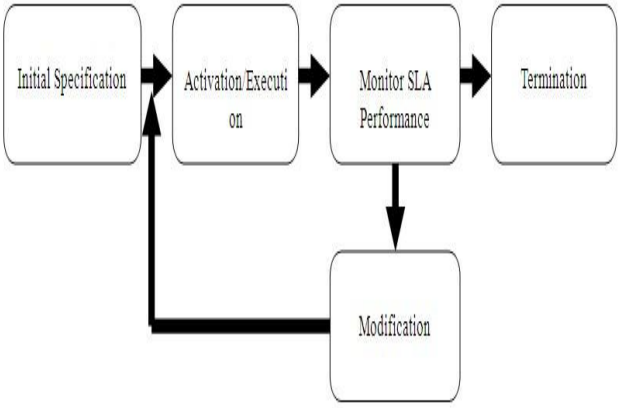

Figure2 The life cycle of SLA

SLA initial specification is important to identify every aspect of service, such as identify business requirements, define service level goal and SLA metrics. The monitor SLA performance let Cloud Bank review current terms, metrics and updates them based on current requirements.

A CBSLA is a service definition. The CBSLA defines an agreed set of service parameters and the way to evaluate this service. There are two parts of CBSLA, one is Resource Provider-SLA (RP-SLA) which is signed by Cloud Bank and resource provider, another part is Resource Consumer-SLA (RC-SLA) which is signed by Cloud Bank and resource consumer.

The Figure3 shows general architecture of Cloud Bank service level management (CBSLA). The provider put their resource into resource pool after quantification and graded by Service level Management (SLM), the RP-SLA contract will be signed after this process. The resources in resource pool are provided as different levels of services according to the resource grade graded by SLM, consumer signs the RC-SLA contract with Cloud Bank when they need services.

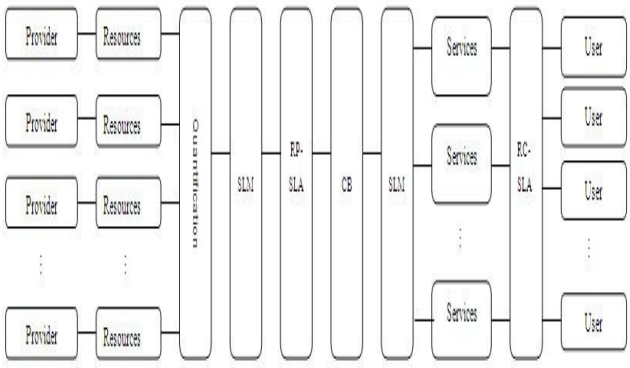

Figure3 The general architecture of Cloud Bank service level management

In this model, it can be noted that each of the activities represents an operation on resources and services. As a result, a RP-SLA can be attached to each of the activities to represent the agreement between Cloud Bank and provider. Similarly, RC-SLA can be attached to the overall process to represent the agreement between Cloud Bank and user.

D. Computational Model of the Parameters in the Predicting Inequality and Monitor Inequality

In the Predicting Inequality and the Monitor Inequality, there are some important parameters: Ad, P_i,P_j,Ad',$P_i'$and P_j'. In the mathematical prediction models, Exponential Smoothing Model [7] is suitable to work out Ad and Ad', Logistic Regression Model [8] is suitable to work out P_i,P_j, $P_i'$and P_j'.

The basic formula for Exponential Smoothing Model is

$$S_t = (a) * Y_t + (1 - a) * S_{t-1} \qquad (3)$$

The basic formula for Logistic Regression Model is

$$\text{logit}\big(Pr(Y = 1|X)\big) = \beta_0 + \beta_1 * X_1 + \cdots + \beta_m * X_m (4)$$

III. THE PARAMETERS IN SLA FOR RISK PREDICTION

As mentioned above, the liquidity risk in Cloud Bank can make the quality of service lower. CBSLA is proposed to guarantee the QoS of Cloud Bank and the Liquidity Risk Predicting Model (LRPM) protects Cloud Bank from the damages caused by these risks. So CBSLA must contain all the information which can make the Liquidity Risk Predicting Model work. But what kind of information should be contained in each CBSLA contract?

The whole LRPM is constituted by two inequalities: (1) and (2). After analyzing the two inequalities, it can be found out that the values of following parameters should be got to make LRPM work: Ad, P_i,P_j,Ad',P_i', P_j', S_i , S_j, $S_i'$and S_j'.

In LPRM, Exponential Smoothing Model is used for computing the values of the parameters Ad and Ad'. In (3), $S_t$is

the smoothing value in cycle t, it means the predicting value in cycle t; Y_t is the actual value in cycle t, it means the actual value of the new added resources in cycle t; S_{t-1} is the smoothing value in cycle (t-1), a is the smoothing constant, its range is [0,1]. Contract term of each contract and the time of system cycle should be contained in every CBSLA contract in order to get the values of the two parameters.

According to the definition of S_i , S_j , S_i' and S_j' , each CBSLA contract should contain resource type, the number of the resources which are lent out or borrowed in and the quality of these resources in order to get the values of the four parameters.

The computation of the parameters P_i,P_j, P_i' and P_j' is a little complex. In LRPM, Logistic Regression Model is used for computing the values of these four parameters. In (4), $\text{logit}(x) = \ln(x/(1-x))$; $Y = 1$ means choosing not to renew the contract. X is the set of the features of a provider or a consumer. $Pr(Y = 1|X)$ is the probability of choosing not to renew the contract under the condition X. $\{X_i\}$ is the set of all the common features; $\{\beta_i\}$ is the set of the model parameters; each β_i can reflect the importance of the X_i to the prediction.

The most important part of the whole Logistic Regression Model is the feature set $\{X_i\}$. Different elements combination in the feature set means different probability. So it is necessary that each CBSLA contract records the features of the RP or RC. The level of each feature should be recorded too. Let's take RP as an example. RP sign contracts before providing resources. When a contract expires, RP will decide whether to renew the contract. The elements of the feature set record some features about the RP and these features can affect the RP when the decision is going to be made. For example, X_1 records the providing time feature which means the time that the RP provides resources in each day. A RP who provides resources during his or her sleeping time has a higher probability to renew the contract than any other situation. Such RP has a higher level of the providing time feature and the value of the parameter X_1 is higher.

But every RP or RC has many features, such as the body height and weight which are useless. So picking up those useful features is the key work in the whole computation of the Logistic Regression Model. Because RP and RC are two different roles in Cloud Bank model, they will be discussed separately.

After analyzing the behavior and motivation of RP when they provide resources, these kinds of features can be picked up: the sensitivity of benefit, the period of providing resources, the ownership of resources and the history records of providing resources.

The sensitivity of benefit means that the RP have different levels of the sensitivity of the benefit paid back by Cloud Bank. The change of the interest of providing resources does not mean the same to all the RP. Think about the similar situation in commercial banks. You don't always move your money to another bank just because of the change of the interest unless you have enough money to make such change meaningful to you. So the number of the providing resources can be a yardstick for measuring the level of the sensitivity. The larger number means higher probability of renewing the contract.

The period of providing resources means that RP will choose different periods in each day to provide resources. Different period means different probability. As mentioned above, a RP who chooses the sleeping time to provide resources has higher probability of renewing the contract and a RP who chooses the working time has a lower probability.

The ownership of resources obviously means who owns the resources. Different ownership means different probability. For example, the resources which owned by a company which have the unstable requirement of these resources has higher probability to be partly drawn back which means partly stopping contract to Cloud Bank when the contract is expired.

The history record of providing resources can help Cloud Bank find out the loyalty of each RP. The more loyal means higher probability of renewing the contract.

The information contained in these features about every RP will help Cloud Bank compute the probability of a RP choosing not to renew the contract and make a timely reaction to avoid liquidity risks.

There is only one feature about RC which can distinguish different probabilities of renewing the contract. It is the usage of resources. All the usages of resources can be divided into three types: only computing, only storage and computing with storage. Only computing means RC just uses the resources to compute. This type of usage only needs CPU, memory and bandwidth. After the whole process of computing, the resources are likely to be returned. The resource requirement of this type is unstable. So RC who has this type of usage has a low probability of renewing the contract. Only storage means RC only borrows disks for storage. RC who has this type of usage has a higher probability of renewing the contract. because the resource requirement is more stable. Computing with storage means RC needs CPU, memory, bandwidth and disks to deal with a complex work. The resource requirement of this type is most stable and RC who has this type of usage has the highest probability of renewing the contract.

All the features mentioned above should be added into the CBSLA as the risk part. These SLA are called CB-RISK-SLA based on CBSLA.

IV. SERVICE LEVEL AGREEMENT TEMPLATE OF CB-RISK-SLA

In [5], a service level agreement template of CBSLA is already presented. But as mentioned above, this template doesn't give solutions in details. CB-RISK-SLA focuses on the risk part and add a new risk part in this template in order to support the Cloud Bank's Liquidity Risk Predicting model.

A. The Hierarchical Model of the CB-RISK-SLA Template

As mentioned above, CB-RISK-SLA template is based on the CBSLA template and adds a new risk part into CBSLA template. The hierarchical model of the CB-RIKS-SLA is shown in Figure 4.

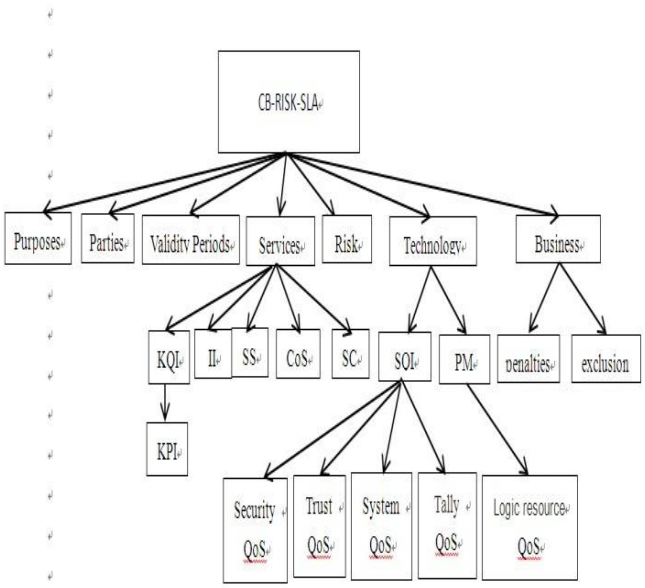

Figure 4 The hierarchical model of the CB-RISK-SLA template

It is obvious that CB-RISK-SLA template adds a part called "Risk". In the Risk part, all the parameters which are mentioned above should be added into this part. Then the Cloud Bank computing platform can get all the needed values from each SLA contract and start the Liquidity Risk Predicting model to guarantee the QoS of Cloud Bank.

B. Details of the Risk Part in CB-RISK-SLA template

The Risk part in CB-RISK-SLA focuses on the risk and is based on the Liquidity Risk Predicting model. There are a lot of parameters related to the risk in this Risk part. The details of the Risk are shown in Figure 5 and it comprises the following major parts:

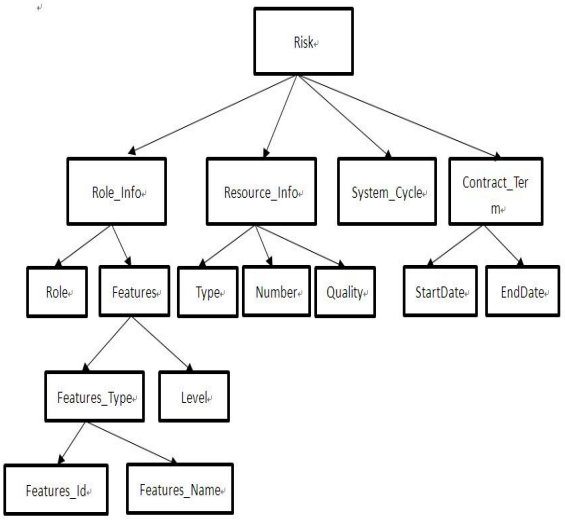

Figure 5 The hierarchical model of the Risk part in CB-RISK-SLA

1) Role_Info: This part records the following information of the RP or RC: Role and Features. The value of the Role part is RP or RC. The parameter Features records the features of each RP or RC and includes two parts: Feature_Type and Level. As mentioned above, there are four kinds of Feature_Type about RP and one kind of Feature_Type about RC. The four kinds of Feature_Type are the sensitivity of benefit, the period of providing resources, the ownership of resources and the history records of providing resources. The one kind of Feature_Type about RC is the usage of resources and there are three kinds of usage: computing, storage and computing with storage.

2) Resource_Info: This part records the resource's information. It contains three parts: Type, Number and Quality. The Type part records the type of the resources. The Type part includes four kinds of type of resources: CPU, Memory, Disk and bandwidth. The Number part records the number of each type of resource. The Quality records the quality of the resources. It is necessary to divide resources by quality in order to offer different kinds of services.

3) System_Cycle: This part records the system cycle of the Cloud Bank computing platform which is needed by the Liquidity Risk Predicting model.

4) Contract_Term: This part records the start time and the end time of each contract. It can help compute out how long each contract last and the contract term is needed by the Liquidity Risk Predicting model.

C. The design decision of CB-RISK-SLA template based on XML

The CB-RISK-SLA template is based on XML and use XML schema to define the syntax. All elements are defined as XML schema types. Every element must be assigned a type that defines the structure of its content. Figure 6 is the XML schema instance of the CBSLA template.

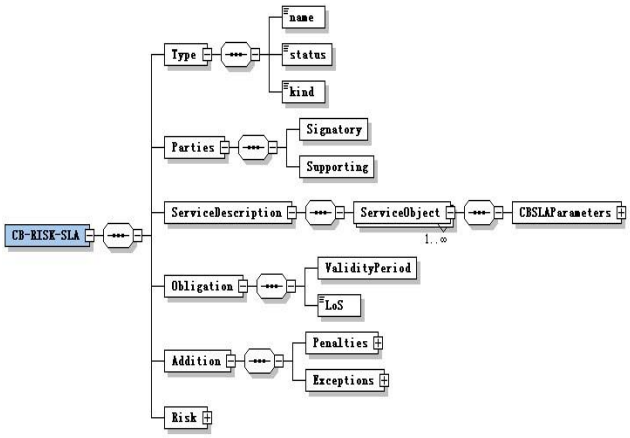

Figure 6 CB-RISK-SLA XML Schema

The details of Risk are shown in Figure 7:

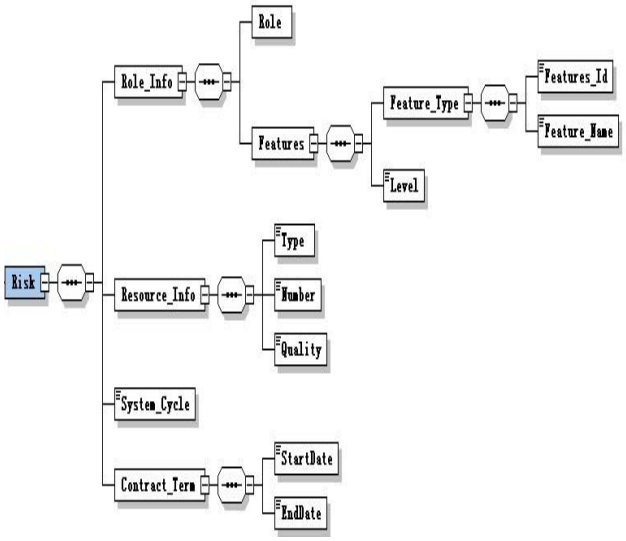

Figure 7 the details of Risk

SUMMARY

Based on the CBSLA, this paper presents a more advantage SLA called CB-RISK-SLA. This new CB-RISK-SLA focuses on the details of the Risk part and contains all the parameters which are needed when Cloud Bank starts its risk against strategies. So this CB-RISK-SLA can help Cloud Bank avoid the damages caused by the transaction risks and guarantee the QoS to resource providers and resource consumers.

But because of the limited time, there are still lots of issues in this CB-RISK-SLA which are not discussed in the paper, such as the features about RP and RC may not be considered all-sidedly. These problems will be the next focus of the research.

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