Why are Reputation Systems Absent from Cloud Services: Reason and Solution

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***Abstract*—Feedback rating-based reputation system is usually considered as an effective approach to build the trust between cloud users and cloud providers. However, unfortunately, such a reputation system is absent from the present major cloud providers, e.g., *Amazon*, *Google* and *Microsoft*, which embarrasses a cloud user from selecting a trusted cloud service from a cloud provider. In view of this challenge, in this paper, we first analyze the cloud characteristics, and study why reputation systems are absent from cloud providers, from perspectives of cloud provider and cloud user respectively. Afterwards, two reputation systems of popular e-Commerce service platforms, i.e., *Amazon.com* and *eBay.com*, are investigated respectively. Finally, a reputation system tailored to cloud services, i.e., Cloud Reputation System (CRS) is brought forth. CRS not only considers the advantages of e-Commerce reputation systems, but also adapts to the cloud characteristics. We believe that the proposed CRS is helpful, for building the trust between cloud users and cloud providers in the future.**

Keywords-Cloud user*; *Cloud provider*; *Trust*; *Feedback rating*; *Reputation system*; *Service quality

I. INTRODUCTION

As a natural evolution of Services Computing, Cloud Computing has recently gained more and more attentions, from both academic and industry domains [1][2]. By delivering various computing resources in a pay-as-you-go manner, Cloud Computing is helping human to realize the long-held dream of computing-as-a-utility. In the cloud environment, a cloud provider could share its idle computing resources for additional income. While on the other hand, a cloud user can also benefit from moving his/her business applications towards cloud, so as to enjoy an easy-to-deploy, maintenance-free and cost-effective business competitive advantage [3].

However, due to the open and dynamic nature of cloud environment, the Quality of Service (QoS) of a cloud service is not always as good as advertised; even a Service Level Agreement (SLA) contract is made beforehand between a cloud user and a cloud provider [4]. We analyzed the reasons as follows. First, inside the cloud provider, we cannot expect the availability of a cloud service is always 100% in a billing cycle (e.g., numerous reported outage incidents [5]). Besides, inside attacks and damages are also possible (for example, *Google* has to fire the employees for their illegitimate operation on user data [6]). Second, outside the cloud provider, we cannot precisely predict the actual execution context (e.g., *network delay*), when a cloud user requests a cloud service from a cloud provider. Besides, malicious attacks from competitors are also inevitable in cloud environment [2]. Therefore, the delivered service quality of a cloud provider is fluctuant, and sometimes may not meet the quality expectation of the cloud user. In other words, cloud provider (or the service delivered by a cloud provider) is not always 'trusted' as promised. Therefore, it is of great significance to build trust between cloud users and cloud providers.

Feedback rating and review are regarded as an effective manner to build trust between service providers and service users, and now widely adopted in present popular e-Commerce service platforms [7]. For example, if one buys a smartphone from an e-Commerce platform, he/she can leave a negative or positive rating (1-star to 5-stars, and 5-star is the best) or review, according to his/her satisfaction towards the smartphone quality and shipping service. However, compared with e-Commerce, present major cloud providers, e.g., *Amazon*, *Google* and *Microsoft* lack such a reputation system. In this situation, if one requests a cloud service from a cloud provider, e.g., *Amazon*, he/she has no way to evaluate and predict the cloud service quality before the service is delivered and executed. Therefore, the absence of reputation system makes it a challenge for cloud users to select a trusted cloud service from cloud providers.

In view of this challenge, in this paper, we study the reasons that reputation systems are absent from cloud providers, and put forward a reputation system tailored to cloud service delivery. The remainder of this paper is organized as below. In Section 2, we analyze the cloud characteristics and study why reputation systems are absent from the present cloud providers. Afterwards, in Section 3, two reputation systems of e-Commerce (i.e., *Amazon.com* and *eBay.com*) are investigated respectively. In Section 4, a reputation system for cloud services, i.e., CRS (Cloud Reputation System, CRS) is put forward, by considering the cloud characteristics analyzed in Section 2 and the e-Commerce reputation systems investigated in Section 3. Related work and comparison analyses are introduced in Section 5, and finally, conclusions are drawn in Section 6.

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II. ABSENCE OF REPUTATION SYSTEM FROM CLOUD PROVIDERS: THE REASONS

Rating-based reputation system is a good supplement for calculating the trustworthiness of a cloud service before its delivery. However, as far as we know, the present major cloud providers (e.g., *Amazon*, *IBM* and *Microsoft*) do not support such a reputation system. In this section, we analyze the reasons from the perspectives of cloud provider and cloud user, which are listed briefly in Table 1.

TABLE I. ABSENCE REASONS OF REPUTATION SYSTEM FROM CLOUD

Perspective	Id	Reason
Cloud provider	**1**	Lack of incentive
	2	Have confidence in delivering high service quality
	3	Fear for malicious ratings
Cloud user	**1**	Hard to rate a cloud service with a long running period
	2	Hard to rate a cloud service in service combination
	3	Hard to observe the necessary QoS data for rating

A. Reasons From the Perspective of Cloud Provider

In this subsection, we study the reasons that reputation systems are absent from cloud, from the perspective of cloud provider.

(1) Lack of incentive

At present, the big and competitive companies constitute the majority of cloud providers. For example, *Amazon* occupies 80%-90% market share of IaaS [8]. In this situation, a cloud user has few choices when he/she requests a cloud service; hence, the big cloud provider, e.g., *Amazon* lacks incentive to build its reputation system. Besides, no competition exists inside a cloud provider. For example, if a cloud user requests elastic computing resources from *Amazon*, he/she has no other choice but to select *EC2* service, because only *EC2* service is able to provide the elastic computing functionality inside *Amazon*. In this situation, *EC2* faces no competition inside *Amazon*. Therefore, from the perspective of *Amazon*, it is regarded as unnecessary to measure and publish the reputation of *EC2*, even if different cloud users may experience different service quality from *EC2*.

(2) Have confidence in delivering high service quality

The big cloud providers, such as *Amazon*, deliver rich cloud services and have advanced techniques to ensure that a high quality service is provided. Therefore, the big cloud providers often have confidence in their delivered service quality, and regard it unnecessary to build a reputation system for their cloud services. For example, as Fig.1 shows, *Amazon* declares 99.99% service availability in its SaaS SLA contract, and different compensation rates are available if the agreed availability is violated [3].

However, as analyzed in Section 1, the service quality delivered by cloud providers is not always as high as promised, due to the malicious attacks from outside, or dynamic change of network environment. Besides, the simple compensation mechanism is not suitable for all cloud users, when SLA agreement is violated. For example, if a critical task is failed due to the poor quality of a cloud service, the user may prefer to leave a lowest rating (e.g., 1-star) to the cloud service, rather than receive a compensation of $100.

Service Level Agreement

Availability

- 99.99% uptime

Compensation

- Percentage of total charges paid by cloud user

UPTIME (PER 15 MIN)	COMPENSATION
99.99% - 100%	0%
98.00% - 99.98%	5%
97.00% - 97.99%	10%
95.00% - 96.99%	20%
< 95.00%	50%

Figure1. An example of SLA contract

(3) Fear for malicious ratings

After a user invoked a service, he/she can give the service a feedback rating, based on the perceived service quality and his/her quality preference. Therefore, the feedback rating is rather subjective, and the feedback rating-based reputation system is vulnerable to the malicious attacks. For example, a malicious user may give a 1-star rating to a 5-star delivered service, or give a 5-star rating to a 1-star delivered service, for commerce or competition reasons. Similar fears are also existent for the cloud providers, because a good reputation accumulated within a long period could be easily damaged by a malicious user rating. Therefore, from the perspective of cloud provider, it prefers to leave the reputation system empty, rather than have its service reputation attacked by potential malicious cloud users.

B. Reasons From the Perspective of Cloud user

Different from the traditional web service, cloud services have some particular characteristics. Next, we will introduce these characteristics, and analyze the reasons that reputation systems are absent from cloud, from the perspective of cloud provider.

(1) Hard to rate a cloud service with a long running period

Different from the traditional web services whose running period is short, the running period of a cloud service is usually long, e.g., one year, during which the cloud provider will deliver its cloud services continuously. In this situation, it is hard for a cloud user to rate a cloud service during its long running period. First, a cloud user

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cannot wait to give his/her final rating until the cloud service's delivery ends, because the waiting time is too long (e.g., a cloud user has to wait for one year, in order to rate his/her requested one-year-period *Email service* from *Google*). Second, the service quality of a cloud service may change constantly, during the service's long running period. Hence, a cloud user cannot give a fair and accurate rating, towards the dynamically changed service quality of a cloud service.

(2) Hard to rate a cloud service in service combination

Generally, a cloud provider delivers its cloud services in the form of service combination. For example, Table 2 lists four cloud service combinations advertised by *Amazon EC2* [9], i.e., {Small instance, Middle instance, Large instance and Extra-large instance}, where each instance is a combination of four categories of cloud services {Memory, EC2 Computing Unit, Local Storage, Platform}.

TABLE II. AN INSTANCE OF CLOUD SERVICE COMBINATION

	Memory (GiB)	EC2 Computing Unit	Local Storage (GB)	Platform (bit)
Small	1.7	1	160	32 or 64
Middle	3.75	2	410	32 or 64
Large	7.5	4	850	64
Extra-large	15	8	1690	64

In this situation, a cloud user can only give an global rating towards the whole service combination instance. For example, a cloud user gives a '4-star' rating to service combination 'Middle instance' in Table 2. Obviously, this rating is a global rating towards the quality performance of combination (e.g., 'Middle instance'), not a local rating for a single cloud service (e.g., '410 GB Local storage' in 'Middle instance'). In this situation, the global rating has little effect in evaluating the service quality of a single cloud service; even if a global rating is given by a cloud user. For example, if a cloud user gives a lowest '1-star' rating to 'Middle instance', we cannot determine whether the bad rating is caused by the poor quality of '3.75 GiB Memory' or '2 EC2 computing unit' or '410 GB Local Storage' or '32 or 64 Platform'.

(3) Hard to observe the necessary QoS data for rating

In cloud environment, business applications of users are deployed and executed on the remote servers of cloud providers, not locally. Therefore, a cloud user has little control on its business execution, and thereby cannot observe the detailed QoS data associated with cloud service delivery, e.g., the actually delivered *disk I/O*, *response time of storage service*. Although several toolkits have been developed to monitor the QoS data of cloud service delivery, e.g., *Amazon CloudWatch* [10], the monitoring range is limited and the monitoring accuracy is doubtable. For example, if a cloud user utilizes *CloudWatch* to monitor *EC2* service, the authenticity of monitored QoS data is doubtable, as both *CloudWatch* and *EC2* are developed by *Amazon*. Therefore, it is hard for a cloud user to rate a cloud service, based on the little observed QoS data.

Based on the above reason analyses, we have identified the obstacles that lead to the absence of reputation system from cloud, from perspectives of cloud provider and cloud user. Next, two reputation systems in e-Commerce, e.g., on-line *Amazon.com* and *eBay.com* will be investigated respectively, which could be regarded as beneficial references for building a reputation system for cloud services in the future.

III. INVESTIGATION OF REPUTATION SYSTEMS IN E-COMMERCE

Although few cloud providers also build their reputation systems, e.g., *Rackspace Inc.* [11], the reputation system is rather simple and cannot accommodate the cloud service delivery very well. In this section, the reputation systems of on-line *Amazon.com* and *eBay.com* will be investigated respectively, which are beneficial references for building a reputation system for cloud services, as e-Commerce and cloud provider both deliver their 'services' to the public.

A. Reputation system of Amazon.com

As a successful on-line mall that delivers thousands of products to people all over the world, *Amazon.com* [12] is famous for its delivered high-quality products and objective reputation system. For each product in *Amazon.com*, a reputation is built, which mainly consists of the following two components: **user rating** and **user review**.

(1) User rating

For each product, a user can leave a feedback rating from '1-star' to '5-star' ('5-star' is the best), to indicate his/her satisfaction degree towards the product quality or service quality. Then according to the ratings from all users, an average rating is assigned to a product. For example, for 'Kindle Fire HD' product, totally 824 users give their ratings, where there are 34 '1-star' ratings, 37 '2-star' ratings, 115 '3-star' ratings, 232 '4-star' ratings and 406 '5-star' ratings. Therefore, the average rating for 'Kindle Fire HD' is '4.1-star'. This average rating could reflect the user-perceived product quality approximately. Besides, the user rating is not fixed, but variable. For example, if 'Kindle Fire HD' cannot work after one month use, the user may revise the pre-assigned '5-star' rating to '1-star' rating, so as to express his/her extreme anger. This kind of variable user rating is really suitable for rating the quality of long-lifecycle products.

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(2) User review

Besides user rating, *Amazon.com* allows users to give their reviews about a product. Considering the above example, 824 reviews are available for 'Kindle Fire HD' product. In a review, a user could describe his/her satisfaction or dissatisfaction, as well as the reasons. Moreover, user B can rate a review from user A ('helpful' or 'not helpful'), which can reflect whether user A's review is helpful to user B. For example, if 100 users read a review from user A, and 98 users consider the review helpful, then a ratio '98/100' is assigned to the review from user A. In this way, *Amazon.com* can avoid some malicious user ratings and reviews.

Despite of the above advantages, the reputation system of *Amazon.com* still has some limitations. For example, anyone can rate a product; even if he/she did not buy this product from *Amazon.com*. In this situation, the reputation system could be easily attacked by malicious users, e.g., by *Sybil attacks* [3].

B. Reputation system of eBay.com

Compared with *Amazon.com*, the reputation system of *eBay.com* [13] is more complicated, which mainly consists of three components: **mutual rating**, **user review** and **Quantity sold**.

(1) Mutual rating

Different from *Amazon.com*, the ratings of *eBay.com* are mutual: **buyer rating** and **seller rating**.

Buyer rating: A buyer can rate the service quality of a seller by buyer rating. If buyer A buys a product from seller B, A can give an overall rating to B, i.e., 'Positive' or 'Neutral' or 'Negative'. Moreover, more detailed ratings could be given, according to the four criteria {*Item as described*, *Communication*, *Shipping time*, *Shipping and handling charges*} of B, each of which could be rated from 1-star to 5-star by A. Therefore, A can give one overall rating and four detailed ratings towards B. For example, buyer A's overall rating towards B is 'Positive', and detailed ratings are respectively {5-star, 4-star, 5-star, 4-star} corresponding to the above four criteria. Besides, according to overall ratings from all buyers, seller B is assigned an overall '99.95% Positive' rating (excluding the repeated ratings from the same buyer in one week) by *eBay.com*. Likewise, according to detailed ratings from all buyers, seller B is assigned a detailed {4.9-star, 4.7-star, 5-star, 4.8-star} rating by *eBay.com*.

Seller rating: A seller can also rate the hehavior of a buyer by seller rating. After the buyer rates the seller, the seller can also rate the buyer as 'Positive' or 'Neutral' or 'Negative'. According to the seller ratings from all sellers, a buyer (e.g., A) is assigned an overall seller rating, e.g., '98.5% Positive' by *eBay.com*.

Time factor is also considered in *eBay.com*. For example, both the buyer rating and seller rating should be given in 60 days since a deal is agreed, and could be revised only once in 10 days since the rating is given. Of course, a buyer can also view the past buyer ratings of a seller, e.g., buyer ratings in recent one month, in recent six months or in recent one year.

(2) User review

The user review of *eBay.com* is similar with that of *Amazon.com*, so it will not be discussed repeatedly. The minor difference between them is that: in *eBay.com*, a review should be given in 60 days since a purchase behavior occurs, and can only be revised once in 10 days after its birth.

(3) Quantity sold

For each product, a 'quantity sold' number is assigned by *eBay.com*, to indicate the popularity of the product in a recent period. For example, '1000 sold last month' shows a great confidence of buyers towards a product recently. Although 'quantity sold' is not a direct component of reputation in e-Commerce, it is still regarded as an important factor when evaluating the reputation of a product.

Next, based on the above analyses, we compare the reputation systems of *Amazon.com* and *eBay.com*, from different angles. The comparison results are listed in Table 3, where better reputation strategies are stressed with a darker background color. Here, for some reputation strategies employed, we cannot determine whether it is good or not, such as the last criterion in Table 3, i.e., 'quantity sold'. According to *eBay.com*, 'quantity sold' is a good indicator towards the popularity and quality of a product; however, according to *Amazon.com*, 'quantity sold' is bad because it distracts users' attention from focusing on the product quality itself. As in Table 3, neither of the two reputation systems can outperform the other.

TABLE III. REPUTATION SYSTEM COMPARISONS: AMAZON.COM VS EBAY.COM

Feedback type \ e-Commerce		Amazon.com	eBay.com
User rating	Overall rating	Yes /1-star to 5-star	Yes /Positive or Neutral or Negative
	Detailed rating	No	Yes
	Mutual rating	No	Yes
	Non-user rating	Yes	No
	Revisable	Yes/anytime	Yes/once in 10 days
	Timely rating	Yes/not must	Yes/in 60 days
	Repeated rating	Yes	No
	Malicious rating	Yes/easy	Yes/difficult
	Mandatory rating	No	No
User review	Timely review	Yes/not must	Yes/in 60 days
	Revisable	Yes/anytime	Yes/once in 10 days
	Rating for review	Yes	Yes
	Malicious review	Yes/easy	Yes/difficult
Quantity sold		No	Yes

IV. A REPUTATION SYSTEM FOR CLOUD SERVICES

In this section, a reputation system for cloud services, i.e., CRS is put forward. Here, CRS does not discuss the concrete reputation calculation process of cloud services, instead, CRS provides detailed solutions for solving the obstacles and difficulties introduced in Section 2, when building a reputation system for cloud services. The details of CRS are listed in Table 4. Next, we explain why the proposed solutions can solve the present obstacles.

TABLE IV. CLOUD REPUTATION SYSTEM CRS: OBSTACLE & SOLUTION

ID	Obstacle	Solution
1	Lack of incentive	Number of invocations
2	Have confidence in delivering high service quality	Overall rating
		Detailed rating
3	Fear for malicious ratings	Mutual rating
		NO Non-user rating
		NO Non-user review
		NO repeated rating
4	Hard to rate a cloud service with a long running period	Revisable rating
		Revisable review
		Timely rating(alternative)
		Timely review(alternative)
		Period rating
5	Hard to rate a cloud service in service combination	Detailed rating
6	Hard to observe the necessary QoS data for rating	Detailed rating
		NO Mandatory rating

Obstacle1: Lack of incentive. According to the Bandwagon Effect [14], the more frequently a cloud service is invoked, the more attractive it is for cloud users. Therefore, 'Number of invocations' is of positive significance, for promoting cloud providers to build their respective reputation systems.

Obstacle2: Have confidence in delivering high service quality. The low 'Overall rating' and 'Detailed rating' data can reminder the cloud providers to improve their poor service quality, so as to avoid cloud providers' overconfidence in their delivered service quality.

Obstacle3: Fear for malicious ratings. The proposed 'Mutual rating' can increase the risk of a cloud user, if he/she gives a malicious rating. Besides, the Non-users are not allowed to give a rating or review, by which we can reduce the malicious ratings or reviews from the Non-users. Furthermore, repeated ratings are not allowed, which can increase the cost of a cloud user when he/she gives a malicious rating.

Obstacle4: Hard to rate a cloud service with a long running period. For the cloud services with a long running period, a cloud user can give his/her timely rating or review after he/she invokes the service. Besides, a user can report the latest service quality rating every other period, which is called 'Period rating'. In order to cope with the dynamic changes of service quality during the long running period, users' rating or review towards a cloud service are revisable.

Obstacle5: Hard to rate a cloud service in service combination. Actually, it is difficult to rate a single cloud service in service combination. However, we can make some attempt under some reasonable assumptions. For example, as Table 2 shows, we assume that *Response time* is affected greatly by the single service 'EC2 computing unit' and likewise, *Throughput* is affected greatly by the single service 'Memory'. Under these two assumptions, we can rate single services 'EC2 computing unit' and 'Memory' approximately, through the 'Detailed rating' towards QoS criteria *Response time* and *Throughput*.

Obstacle6: Hard to observe the necessary QoS data for rating. With the limited QoS data that is observed, a cloud user can give its detailed ratings towards few or partial QoS criteria, which is still of positive significance for future cloud service selection. Besides, mandatory rating is not allowed so as to ensure the authenticity.

V. RELATED WORK AND COMPARISON ANALYSES

Cloud computing has exhibited its great advantages in delivering use-on-demand and pay-per-use computing services [1][2][15]. More and more users are moving their business or personal applications towards cloud. However, due to the dynamic and open nature of cloud environment, a cloud service may not deliver a satisfactory quality level as promised in its SLA contract. In other words, from perspective of a cloud user, a cloud service is not always 'trusted' during its delivery period. Many researchers have observed and studied this trust problem.

Academic area. SLA is considered as a feasible manner to build trust between a cloud user and a cloud provider [2]. A cloud provider is regarded as trusted, if its service is delivered with SLA-agreed quality. Sheikh Mahbub Habib, et al. [15] introduces a set of attributes, e.g., *security*, *performance* and *compliance*, to monitor and measure the SLA violation. However, some quality performance declared in SLA is hard to monitor directly. Therefore, as an indirect manner, Monoj Kumar Muchahari, et al. [16] proposes a feedback rating-based trust calculation method, i.e., *TrustCalculator*, to estimate the future quality of a cloud service, based on its past feedback ratings from cloud users. However, the assumed user rating is of a rather simple form, i.e., from 0 to 5, which cannot accommodate the complicated cloud service delivery very well. As malicious rating is possible, S. Wang, et al. [17] proposes a detection method of malicious rating, by comparing the monitored service quality and the expected service quality in SLA. The object of this proposal is to ensure that all the user ratings are real and trusted, not malicious, which has the same function as our proposed 'Mutual rating' and 'Rating for review' in *R3*. Talal H. Noor, et al. [18] proposes a *Trust Feedback Collector* to collect user feedbacks from cloud service delivery. This collector provides an essential foundation, for building our proposed *R3* reputation system in cloud.

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Industry area. Compared with the enthusiasm in academic area, few progresses in industry area could be found in building a cloud reputation system. Concretely, only few cloud providers offer their reputation systems, e.g., *Rackspace Inc.* [11]. And the effect is not as good as expected, for example, only 45 user reviews are left in *Rackspace* reputation systems since 2009. In contrast, most major cloud providers, e.g., Amazon, Google and Microsoft don't offer sufficient reputation systems to support the trust evaluation of their cloud services, which is the major motivation of our paper. In view of the disappointed industry status, we analyze the reasons that reputation system is absent from cloud industry, and introduce a *R3* reputation system tailored for cloud service delivery, by using reputation systems in e-Commerce for reference.

VI. CONCLUSIONS

Feedback rating-based reputation system is a promising way, to build trust between cloud users and cloud providers. However, nowadays, major cloud providers, e.g., *Amazon*, *Google* and *Microsoft* do not support such a reputation system, which hampers a cloud user from selecting a trusted cloud service before the service is executed. In view of this challenge, in this paper, we first study why reputation systems are absent from cloud providers. Afterwards, we put forward a novel reputation system CRS tailored to cloud service delivery. In the future, we will refine the proposed CRS reputation system by introducing more detailed and quantified reputation calculation formulas.

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