A Novel Incentive Mechanism for Truthful Performance Assessments of Cloud Services

(Extended Abstract)

Lie Qu
Macquarie University
Sydney, NSW 2109, Australia
lie.qu@mq.edu.au

Yan Wang
Macquarie University
Sydney, NSW 2109, Australia
yan.wang@mq.edu.au

Mehmet A. Orgun
Macquarie University
Sydney, NSW 2109, Australia
mehmet.orgun@mq.edu.au

ABSTRACT

The performance evaluation of cloud services usually relies on continual assessments from cloud users. In order to elicit continual and truthful assessments, an effective incentive mechanism should allow users to provide uncertain assessments when they are not sure about the real performance of cloud services, rather than providing untruthful or arbitrary assessments. This paper a novel uncertain-assessment-aware incentive mechanism. Under this mechanism, a rational user not only has sufficient incentives to continually provide truthful assessments, but also would prefer providing uncertain assessments over untruthful or arbitrary assessments since uncertain assessments can bring more benefits than untruthful or arbitrary assessments.

Keywords

Incentive Mechanism, Uncertain Assessments, Cloud Services

1. INTRODUCTION

In cloud environments, service performance may vary substantially and frequently due to the dynamic nature of cloud services. Thus, continual assessments over time are needed to effectively reflect the dynamic performance of services. However, eliciting continual and truthful assessments from self-interested cloud users is still a challenging problem.

To motivate users, an effective incentive mechanism should be designed. A common solution is that a cloud user can be paid if he/she provides assessments on schedule. The monetary rewards may be provided by some professional cloud evaluation organizations, such as CloudReviews[1], the aim of which is to provide cloud selection services to potential cloud consumers based on cloud users' assessments and therefore earn profits from the potential consumers. However, such a simple mechanism cannot prevent a user from "free-riding" (i.e., providing arbitrary assessments) [2, 3]. Moreover, sometimes an honest user could also provide arbitrary assessments in order to obtain monetary rewards when he/she does not really know the real performance of cloud services. Such arbitrary assessments may be erroneous and misleading. To avoid the submission of such arbitrary assessments, an effective incentive mechanism should allow honest users to provide uncertain assessments to express their uncertainty about service performance when necessary.

In this paper, we propose an uncertain-assessment-aware incentive mechanism for eliciting continual and truthful assessments of cloud services. Under this mechanism, a user can receive monetary rewards from a *broker* for regularly providing assessments on schedule, where truthful assessments would bring the most rewards; uncertain assessments would bring less rewards; untruthful or arbitrary assessments would bring the very least rewards. Through our mechanism, a rational user would choose his/her best option, i.e., providing truthful assessments. Once he/she is not sure about service performance, there still exists a second-best option, i.e., providing uncertain assessments.

[1]www.cloudreviews.com

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2. THE PROPOSED MECHANISM

2.1 The Uncertain-assessment-aware Assessment Scheme

A cloud user can give his/her assessments for different performance aspects of cloud services. For any type of an assessment system, an uncertain state can be added into the system to express users' uncertainty about service performance. For example, if a rating scheme consists of three states: "good", "fair" and "poor", the uncertain-assessment-aware assessment scheme is composed of four states, i.e., "good", "fair", "poor" and "uncertain", where the first three are considered as the *certain* assessments.

2.2 Game Setup

A broker requires cloud users to provide continual assessments at regular time intervals. A user can get paid if he/she provides an assessment in a scheduled time window. In each time window, the broker must pay each user no matter what kind of an assessment (certain or uncertain assessment) the user gives. The amount of payment has two levels. If a user gives a certain assessment, he/she would get a payment P regardless of the value of the assessment. Conversely, if a user gives an uncertain assessment, he/she would get a discounted payment λP for $\lambda \in [0, 1]$ since uncertain assessments cannot benefit the broker but the user still tells the truth. Thus, the payment from the broker in our framework can be considered "*ex-ante*" [3] with two amount levels. Here,

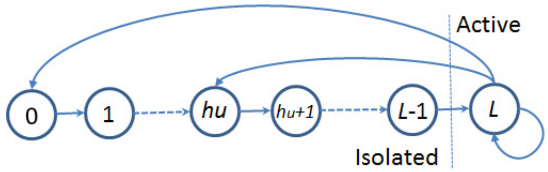

Figure 1: The Assessment Scoring Scheme

such compulsory payments aim to prevent the broker from "false-reporting" [1].

2.3 The Assessment Scoring Scheme

In order to make a user's dominant strategy cooperation (i.e., providing truthful assessments), we propose an assessment scoring scheme to control users' participation in the transactions of selling their assessments. A user has an assessment score to determine if he/she can sell his/her assessments to the broker in a time window. An assessment score θ is a positive integer from a nonempty finite set Θ ($\theta \in \Theta = \{0, 1, 2, \cdots, L\}$), where L is the largest score.

At the end of each time window, the broker can judge whether an assessment is truthful or untruthful by employing an approach such as the majority opinion. According to the broker's reports and users' current assessment scores, a user' score would be updated at the end of each time window. However, there may exist an error probability α of the broker falsely reporting without intention, e.g., a truthful assessment is reported as an untruthful one, and vice versa.

Let $\tau(\theta, b)$ denote the assessment scoring scheme, and the new score of a user at the end of a time window is computed as follows:

$$\tau(\theta, b) = \begin{cases} L, & \text{if } \theta = L \text{ and } b = T, \\ h_U, & \text{if } \theta = L \text{ and } b = U, \\ 0, & \text{if } \theta = L \text{ and } b = UT, \\ \theta + 1, & \text{if } \theta < L, \end{cases} \tag{1}$$

where θ is a user's current score and b is his/her reported behavior. h_U can be considered as a punishment level for users providing uncertain assessments. A user can be reported as having three types of behaviors, i.e., providing *truthful* (T), *uncertain* (U) or *untruthful* (UT) assessments. Figure 1 shows the scoring scheme. All users can be classified into two groups: active users and isolated users. If a user is considered to give a/an uncertain or untruthful assessment, he/she would be punished by being prohibited from selling assessments for a period of time. If a user is not be able to behave cooperatively for some reason, he/she has a second-best option, i.e., giving uncertain assessments, since $0 < h_U < L$.

2.4 Effective Incentive Mechanism Design

In order to build an effective incentive mechanism, we need to analyze the long-term expected payoffs that an "honest" user can obtain and find out what values of L and h_U are necessary for an effective incentive mechanism.

Let $p(\theta'|\theta)$ denote the transition probability of an honest user's assessment scores between two adjacent time windows, where θ represents the user's current score and θ' is the user's new score. Suppose that α is the error probability of the broker making a false judgement about the user's assessment, and β is the probability of the user giving an uncertain assessment in a time window. Hence, an honest user's long-term expected payoff in a time window can be computed by solving the following recursive equation:

$$v^{\infty}(\theta) = v(\theta) + \delta \sum_{\theta'} p(\theta'|\theta) v^{\infty}(\theta'), \text{for all } \theta \in \Theta, \tag{2}$$

where $v^{\infty}(\theta)$ denotes a user's long-term payoff when he/she has the assessment score θ in a time window; $v(\theta)$ denotes the user's instant payoff after giving his/her assessment in the current time window; and $\delta \in (0, 1)$ represents a user's patience about his/her future payoffs. A larger δ means that the user cares more about its future payoffs, and vice versa.

Suppose γ is the probability that a free-riding user guesses the right result of cloud performance. P is the full payoff a user can obtain by giving a certain assessment. C is the cost of the effort for a user providing a truthful assessment, where $P > C$.

We study an active user's long-term expected payoff. If a user provides a *truthful* (T) assessment in a time window, and then his/her long-term expected payoff can be computed as follows:

$$v_T^{\infty}(L) = P - C + \delta[(1-\alpha)v^{\infty}(L) + \alpha v^{\infty}(0)]. \tag{3}$$

And if a user provides an *uncertain* (U) assessment, his/her payoff can be computed as follows:

$$v_U^{\infty}(L) = \lambda P + \delta[v^{\infty}(h_U)]. \tag{4}$$

If a user provides an *untruthful* (UT) assessment, his/her payoff can be computed as follows:

$$v_{UT}^{\infty}(L) = P + \delta[\alpha v^{\infty}(L) + (1-\alpha)v^{\infty}(0)]. \tag{5}$$

Likewise, the long-term payoff a free-riding user can obtain is computed as follows:

$$\begin{aligned} v_F^{\infty}(L) = P + \delta\{\gamma[(1-\alpha)v^{\infty}(L) + \alpha v^{\infty}(0)] + \\ (1-\gamma)[\alpha v^{\infty}(L) + (1-\alpha)v^{\infty}(0)]\}. \end{aligned} \tag{6}$$

Hence, in order to determine the unique dominant strategy and the second-best strategy, an effective incentive mechanism in our framework should satisfy the constraints:

$$v_T^{\infty}(L) > v_U^{\infty}(L), v_U^{\infty}(L) > v_F^{\infty}(L), v_U^{\infty}(L) > v_{UT}^{\infty}(L). \tag{7}$$

3. CONCLUSION

This paper has proposed a novel incentive mechanism for eliciting continual and truthful assessments of cloud services, the main novelty of which is to consider uncertain assessments. Through an assessment scoring scheme, a user would have a dominant strategy (giving truthful assessments) and a second-best strategy (giving uncertain assessments). Hence, our proposed mechanism can protect a user's honesty of providing assessments in unavoidable situations.

REFERENCES

[1] M. Feldman, C. H. Papadimitriou, J. Chuang, and I. Stoica. Free-riding and whitewashing in peer-to-peer systems. *IEEE Journal on Selected Areas in Communications*, 24(5):1010–1019, 2006.

[2] D. Lopez-Pintado. The spread of free-riding behavior in a social network. *Eastern Economic Journal*, 34(4):464–479, 2008.

[3] Y. Zhang and M. van der Schaar. Reputation-based incentive protocols in crowdsourcing applications. In *IEEE INFOCOM*, pages 2140–2148, 2012.