Review of Pricing Techniques in Cloud Computing

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ABSTRACT

Cloud computing offers computing services to its customers at a certain price. The price at which these services are offered determines the revenue of the Cloud Provider (CP) and the amount to be paid by customer (i.e. bill) for consuming the requested services. Ideally, pricing scheme must be transparent and fair i.e. it should give clear idea to users about how they are charged, and must produce fair bills for them. This helps in building reputation of provider and thus attracts more customers. The pricing scheme should also generate fair revenues for the providers. This paper performs a literature review of pricing schemes in Cloud computing with the main aim to identify a suitable pricing scheme which is beneficial for both user as well as provider. The literature review provides an overview of various techniques of pricing, their advantages as well as limitations.

Keywords: Cloud Computing, Pricing Techniques, Instance Types, Revenue

I. INTRODUCTION

Cloud computing has been coined as an umbrella term to describe a category of sophisticated on-demand computing services initially offered by commercial providers, such as Amazon, Google, and Microsoft. It denotes a model on which a computing infrastructure is viewed as a "cloud," from which businesses and individuals access applications from anywhere in the world on demand [1]. In Cloud computing, a provider leases its computing resources in the form of virtual machine instances to users, and a price is charged for the period for which they are used [2]. When the resources are requested by users, they are provided as per Service Level Agreement (SLA) by the CP. An SLA is a contract established between CP and its users, that defines the terms and conditions of the services to be provided by the CP. This agreement includes the pricing mechanism of the resources offered by CP to its users.

A cloud computing provider's typical goal is to maximize its revenues with its employed pricing scheme, while its customers' main goal is to obtain the highest level of quality of service (QoS) feasible for a reasonable price. Therefore, satisfying both parties requires an optimal pricing methodology. The price charged is one of the most important metrics that a service provider can control to encourage the usage of its services [3]. The pricing scheme generally used by public clouds, such as Windows Azure [4] and Amazon EC2 [5] for their VM instances is, *pay as you go* pricing mechanism, where a user is charged a fixed price per unit time per instance.[6] e.g. Amazon EC2 charges per small instance hour at $0.085 [7]. This pay-as-you-go model lets users utilize a public cloud at a fraction of the cost of owning a dedicated private one, while allowing providers to profit by serving a large number of users [8]. Although usage-based pricing model is adopted by most

providers, there are different versions of it in practice. For example, Salesforce.com [9] charges a monthly subscription fee to its users for accessing its online CRM software applications. Amazon Elastic Computing Cloud (EC2), the leading Infrastructure-as-a-Service (IaaS) provider, charges users by hour. Cloud Sigma [10], an emerging IaaS provider from Switzerland, also charges customers by hour, but its billing segment is as short as 5 minutes [11].

Apart from the pricing schemes already used by the commercial CPs, a large number of other pricing techniques have been proposed by researchers. The aim of this paper is to present an exhaustive review and comparison of all the existing pricing mechanisms in Cloud computing to consolidate the work done so far in this area of research.

The paper is organized as follows. Section 2 presents a general overview of pricing. Section 3 discusses and performs a comparative review of pricing techniques proposed in single provider Cloud environment. Drawbacks of the pricing strategies are described in Section 4. Section 5 concludes the paper.

II. PRICING IN CLOUD COMPUTING

2.1 General Pricing Schemes

Two broad categories of pricing mechanisms are: Fixed and Dynamic. CPs usually charge users based on different variations of these pricing mechanisms.

Fixed pricing is the simplest pricing scheme in which fixed prices are charged for the resources irrespective of customer characteristics. It is not based on real-time market conditions [12]. Examples are 'subscription based' and 'pay per use' pricing.

Dynamic Pricing is the practice of charging consumers different prices for the same product or service depending on either distinguishing characteristics of the transaction or of the consumers. For example pricing based on workload, future demands and cloud market fluctuations etc.

As already discussed, currently most of the commercial CPs use 'pay as you go' based fixed pricing scheme. Amazon has recently introduced spot pricing [13] which is a dynamic pricing scheme based on user's bidding price. It also offers 10 different virtual machine instance configurations, with different prices for each configuration, and practice tiered pricing for storage and bandwidth [7]. This can also be considered as a kind of dynamic pricing, where users can request for custom configurations with multiple resource types [14].

2.2 Pricing based on instance types

Infrastructure as a Service Cloud providers usually offer two well-known payment plans to its customers: on-demand and reservation [15]. Apart from these, Amazon, one of the leading commercial Cloud Provider offers yet another way of pricing: spot pricing [13]. The VM types offered on the basis of these plans are: On-demand, Reserved and Spot respectively. Pricing mechanisms of these VM types are explained below:

1) On-demand: On-demand VMs allow customers to pay for compute capacity based on usage without long term commitment. Price is calculated at a fixed rate per usage time, e.g. hourly, from the time an instance is launched until it is terminated. If the provider possesses enough resources, resource provisioning for VM

requests is done, otherwise the request is rejected by the provider. After instantiation of VMs, customers can retain machines as long as they require them. [16]

2) Reserved: Customers pay in advance to reserve the instances for the possible future usage and in exchange receive a significant discount on the charge for running VMs in the reserved capacity. Moreover, customers receive higher availability of the service for reserved than on-demand instances. It is beneficial for both customers as well as providers. On one hand, reservation plans allow the customers to acquire resources at cheaper price and higher availability than that of on-demand plans. On the other hand, it helps providers to attain more efficient resource management and procurement as resources are already reserved [15].

3) Spot: Spot VMs allow customers to reduce the cost of using VMs by accepting the risk of being canceled in favor of customers who are willing to pay more for the same resources. In this model, customers submit a spot VM request, including the number of spot VMs they want to instantiate, and the maximum price they are willing to pay per VM/hour, called bid. If the bid exceeds the current price, the request is served and VMs are instantiated. Otherwise, no VM is launched and the request remains in a pending state in the queue until the spot price goes below the bid price. VMs will run until either the customer decides to terminate them or the price goes above the bid [16].

III. REVIEW OF PRICING TECHNIQUES IN SINGLE PROVIDER CLOUD ENVIRONMENT

Pricing issue in Cloud Computing has been addressed by many researchers and different variants of fixed and dynamic pricing schemes have been proposed.

Xu and Li [17] show that a uniform price does not suffer any revenue loss compared to first-order price discrimination. Pricing algorithm given by Li and Liu [18] is based on historical usage of resources. Huang and Ma [11] discuss the possibility of simultaneously using multiple pricing methods for better resource utilization; and its benefit for the provider and users are studied. Ibrahim et al. [19] discuss that there is a variation in the user's actual costs of the resources consumed, due to the interference among concurrent virtual machines in the pay-as-you-go pricing scheme which causes unfairness among different users. A new pay-as-you-consume pricing scheme is proposed, which charges users according to their effective resource consumption excluding interference. Price of the cloud service has been dynamically calculated based on the load condition of the cloud infrastructure in Narayan et al. [20]. Time period of utilization of the cloud service is divided into time slots. The pricing for every time slot is published and consumers can query for the same. Kantere et al. [21] focus on pricing of cloud applications that offer data management services and support caching of data. A novel price-demand model designed for cloud cache and a dynamic pricing scheme for queries executed in the cloud cache is proposed. The pricing solution employs a novel method that estimates the correlations of the cache services in a time-efficient manner. Hadiji et al. [22] address constrained pricing (resource constraint) problem in a cloud computing environment using game theory. The user's utility is modeled as a function of resource demand with a corresponding price. The game consists in the cloud provider suggesting differentiated prices according to

demand and users updating their requests in view of the proposed price. The objective is to determine the optimal suggested prices by the cloud-provider and the optimal user demands. Macías and Guitart [23] deal with the problem of offering competitive prices in Cloud Computing markets. A Genetic Algorithms approach is proposed, in which a naive pricing function evolves to a pricing function that offers suitable prices in function of the system status. Laatikainen et al. [24] evaluated the SBIFT pricing model and updated it to cloud context by proposing a 7-dimensional cloud pricing framework that helps provide a systematic way to describe the pricing models in order to help decision makers plan, develop and speak about pricing alternatives.

Apart from the primary studies discussed above, some secondary studies are also available in the literature.

In Samimi and Patel [25], a comparative review of pricing models of cloud computing and grid computing is provided. Four pricing models of cloud computing are discussed. Out of these, only two are directly from pricing domain and are relevant. So, the number of pricing models discussed is very less to get an overview of pricing schemes available in the literature and thus, draw any conclusions.

Roomi et al. [3] presented a review of many cloud computing pricing models and schemes. The pros and cons of each model have also been discussed. Many factors that affect pricing and user satisfaction, such as fairness, QoS, and more, have been considered by highlighting their importance in recent markets. Though inclusive assessments and comparisons between several recent pricing models in cloud computing is provided but there are still so many schemes available in the literature that have not been discussed in this paper.

As a whole, the above two secondary studies do not provide a thorough review of the pricing models of Cloud computing.

Keeping this in view, a comparative review of the pricing models of cloud computing has been performed in the below TABLE:

Table 1: Comparative Review of Pricing Models

Paper	Instance Type	Pricing Scheme Used	Benefits	Implementation
Ibrahim et al. [19]	On-demand	Charges users according to their effective resource consumption excluding interference.	1. Reflects the real cost of executing the task and provides a fair cost to users.	Not implemented
Shang et al. [26]	On-demand	A double auction Bayesian Game-based pricing model is suggested for cloud market and an optimal pricing strategy for this model is discussed.	1. Offers reasonable pricing.	Not implemented

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Xu and Li [2]	Spot	The spot price is determined by the provider according to instantaneous demand and supply.	1. Simple to implement and maintain. 2. Avoids the possible collaborative bidding to game the market.	Verified through Numerical Studies
Narayan et al. [20]	On-demand	Dynamic pricing based on load.	1. Real time calculation of price. User may decide to continue or quit service at the beginning of each time slot.	Not Implemented
Sharma et al. [27]	Pricing done irrespective of VM type	Cloud resources pricing function is modeled as an option pricing problem and Cloud resources price are modeled using a continuous time approach.	1. Provides a high satisfaction guarantee measured as Quality of Service (QoS) from users perspectives. 2. Provides profitability from the cloud service provider's perspectives.	Simulation
Kantese et al. [21]	NA	Pricing scheme designed for a cloud cache that offers querying services and aims at the maximization of the cloud profit.	1. Estimation of correlations of the cache services in a time-efficient manner. 2. Achieving optimal pricing for the services of a cloud cache.	Simulation
Hadiji et al. [22]	On-demand	Pricing based on theoretical model using Stackelberg game is proposed.	1. Revenue of CPs is Maximized. 2. User's utilities are maximized.	Evaluation via numerical results

Macías and Guitart [23]	On-demand	Genetic Algorithm approach based pricing: define a chromosome, evaluate it, and finally select the best pairs of chromosomes for reproduction	1. It is easy to implement. 2. Genetic providers earn more than utility-based dynamic pricing providers as well as fixed pricing provider.	Simulation

IV. DRAWBACKS OF PRICING SCHEMES IN THE LITERATURE

The problems associated with the above discussed pricing schemes are mentioned below:

- A pricing mechanism must consider user aspects like contribution to fulfillment of SLA, providing QoS to user, generation of fair bills for user as well as CPs aspects like providing profit, genuine revenue to CP etc. None of the existing schemes takes into account all these aspects. Instead, pricing problem has been addressed keeping in view just one or two aspects.

- Most of the pricing strategies are either theoretical or have been verified/validated through simulation. They have not been implemented in the real scenario i.e. they have not yet been used by any of the commercial CPs.

- In few papers, dynamic pricing has been proposed. But due to lack of proper experimentation of these techniques and reluctance of adoption of new pricing techniques by commercial CPs, their implementation in near future is doubtful.

- Most pricing models have been developed keeping in view the benefits of CP only. The objective is on revenue maximization through appropriate pricing mechanism. The interest of user has not been taken into consideration i.e. the techniques are CP centric.

V. CONCLUSION

Cloud providers offer resources to its users using different pricing schemes. Pricing is one of the major factors that determine the bills generated for user and revenue earned by CP. A large number of pricing techniques have been proposed in the literature for Cloud computing. A review of these techniques has been performed in the paper. Advantages and shortcomings of different technique have also been discussed. From the analysis of literature it has been observed that the proposed pricing models in the literature have not been implemented in the real market scenario. Most of the techniques do not consider various attributes related to user like QoS, user utility etc. In fact, they are focused towards increasing CP's revenue through appropriate pricing and are thus, biased towards CP. Therefore, there is a requirement to propose a pricing scheme that takes into consideration

benefits of both user as well as provider while charging users for the resources consumed. Such a pricing scheme must also be easily adoptable by commercial CPs.

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