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Cloud Computing Pricing Models: A Survey

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Abstract: ***Cloud computing is emerging as a promising field offering a variety of computing services to end users. These services such as infrastructures, platforms and applications could be accessed on-demand whenever it is needed. In Cloud Computing, different types of resources would be required to provide services, but the demands such as requests rates and user's requirements of these services andthe cost of the required resources are continuously varying. Therefore These services are offered at different prices using various pricing schemes and techniques. Customers will favor the service provider offering the best QoS with the lowest price. Therefore, applying a fair pricing model will attract more customers and achieve higher revenues for service providers. This paper provides a survey on cloud pricing models and analyzes the recent and relevant research in this field, and comparing many employed and proposed pricing models techniques and highlights the advantages and disadvantages of each. The comparison is based on many aspects such as fairness, pricing approach, mechanisms, and implementation.***

Keywords: Cloud Computing, Cloud Pricing

1. Introduction

Cloud computing is one of the most popular techniques in distributed computing which will increase scalability and flexibility in computer processing due to its ability to minimize the cost of time calculations. Provides resources and shared services through the internet.

Cloud computing providers offer many services to their customers , including infrastructure as a service (IaaS), platform as a service (PaaS), software as a service (SaaS),storage as a service (STaaS), security as a service (SECaaS), test environment as a service (TEaaS), and many more. 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[1].

Cloud provider offers different services to cloud consumers different prices, therefore, two stakeholders – cloud provider and cloud consumer - would be communicated and negotiated about several things such as QoS, price, etc. All of the negotiation points would be written in SLA clearly. Pricing represents an important indicator for success business companies which provide services or products [3].

Pricing is a critical factor for organizations offering services or products. How the price is set affects customer behavior, loyalty to a provider, and the organization's success. Therefore, developing an appropriate pricing model will help achieve higher revenues. The price determined for a service or product must consider the manufacturing and maintenance costs, market competition, and how the customer values the service or product offered [1] .

Cloud services providers are adopting a variety of pricing approaches , including usage-based fixed pricing, usage-based dynamic pricing, subscription-based pricing, reserved services contracts with a combination of usage-based fixed pricing and up-front fees, and auction-based pricing[2].

The structure of this paper is as follows. Beside this section, the second section will describe briefly cloud computing architecture. The third section illustrates some of pricing models and factors; fourth section is comparison between different cloud commuting pricing models. And finally, yet importantly, our conclusions are presented in the fifth section.

2. Cloud Computing Architecture

Cloud computing is fastest implementation technology. Amazon, Google, Microsoft all are using cloud computing and working towards providing powerful, reliable and logical platforms to its users. A cloud computing architecture consists of three service models, five key characteristics and four cloud computing deployment models that are shown in following Figure 1.[4] .

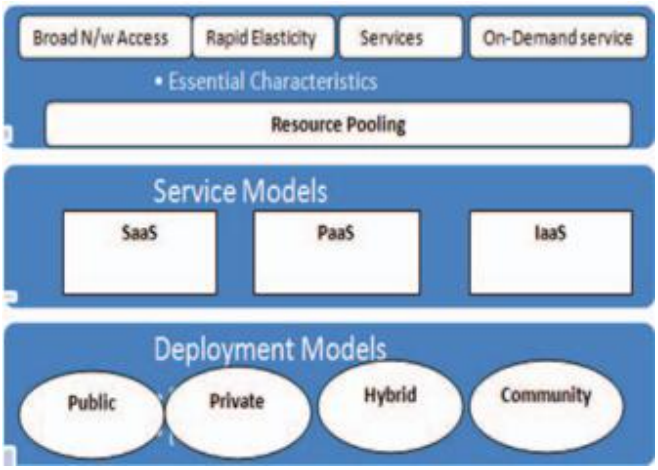

Figure 1: Shows the deployment models of cloud computing. It also defines the service models of cloud computing and its essential characteristics [4]

2.1 Cloud Computing Deployment Models.

Cloud computing is an internet based service that allocates services to the users on demand at any instance of time. There are several types of clouds that provide computing services. These are:

- *Public Clouds*: The cloud infrastructure is available to the public on a commercial basis by a cloud service provider. This enables a consumer to develop and deploy a service in the cloud with very little financial outlay compared to the capital expenditure requirements normally associated with other deployment options. This environment can be used by the general public. This includes individuals, corporations and other types of organizations [5].
- *Private Clouds*: The cloud infrastructure has been deployed, and is maintained and operated for a specific organization. The operation may be in-house or with a third party on the premises. This cloud computing environment resides within the boundaries of an organization and is used exclusively for the organizations benefits. These are also called internal clouds. They are built primarily by IT departments within enterprises who seek to optimize utilization of infrastructure resources within the enterprise byprovisioning the infrastructure with applications using the concepts of grid and virtualization [5].
- *Hybrid Clouds*: This is a combination of both private and public cloud computing environments. The cloud infrastructure consists of a number of clouds of any type, but the clouds have the ability through their interfaces to allow data and/or applications to be moved from one cloud to another. This can be a combination of private and public clouds [5].
- *Community Clouds*: The cloud infrastructure is shared among a number of organizations with similar interests and requirements. This may help limit the capital expenditure costs for its establishment as the costs are shared among the organizations. The operation may be in-house or with a third party on the premises [5, 6].

2.2 Cloud Computing Service Models

Cloud computing provides various types of services to its users [5,7] :

Infrastructure as a Service (IaaS): It consists services that permit its consumers to request storage and computational resources on demand. And also enabling the so called "pay-per-use" paradigm. An example of IaaS is Amazon EC2 .

- *Platform as a Service (PaaS) :* It contains high levels of services that provides a platform to develop andmanage the software infrastructure. In PaaS developer can built and deploy different types of applications using libraries, languages and tools handled by the cloud service providers. Google App Engine is an example of PaaS.
- *Software as a Service (SaaS) :* SaaS comprises end users applications that are delivered to consumers as a network services. So, this eliminates the need to install and run different applications on consumer's computers. An example of SaaS is Google mail.

3. Pricing Models and Factors

This section is divided to two main subsections; the pricing model classifications section and the pricing factors section.

3.1 Cloud Computing Pricing Model Classification

The two common types of pricing model are:

- *Fixed Pricing Model:* In this model the price charging doesn't change, and the cloud provider is someone who determines the price to the resource type in advance. Fixed pricing model is more straightforward and easy to understand, but it is unfair for all customers because they are not having the same needs [8,9,10].
- *Dynamic Pricing Model:* In this model the price charging changes dynamically according to market status quo. The service price could be calculated for each request according to the pricing mechanism that is used. In this case, service consumer requests and receives several types and levels of services in need, such as Market-dependent pricing model [8, 9, 10].

Table 1, shows the advantages and disadvantages between these two classification model.

Table 1: Comparison between fixed pricing and dynamic pricing

Pricing Model	Advantages	Disadvantages	Appropriate
Fixed Pricing Model	1- Supports assurances for consumers.	1- Unfair for consumer, if the user doesn't consume the resources.	Small Organization
	2- Consumers know how much they pay.	2- Does't allow provider to change parice at any account.	
	3-Reduces risks.	3-Unfair for provider: During proper resource utilization consumer may pay less than his/her real utilization.	
	4- Make profit estimation easy.	1- Some consumers are not interested in this model as they prefer a fixed price to dynamic price.	
Dynamic Pricing Model	1- It supports provider to maximize profits with each consumer.	2- Consumers who pay more feel inequality consequently having negative opinions.	Large Organization
	2- Fair for consumer as it enables him to pay according to the offered QoS.	3- In some environments such as entertainment sites consumers do not prefer dynamic pricing.	
	3- It supports provider to set price based on current state of the market (season or supply and demand)		

3.2 Pricing Factors

There are many factors that affect the pricing incloud computing, in this section we briefly illustrate the most important factors:

***The annual costs*:** The amount of many that the service provider spends annually to buy resources [11, 12].

The lease period: The period, during which the customer leases resources from the service provider, the price will be reduced if the leasing period is long [11, 12].

Quality of services: The set of technologies offered by the provider to enhance the user experience in cloud, such as data privacy, and resource availability [11, 12].

Pricing scheme: The mechanism which in the service price cloud be determined, such as reserved model, on-demand model [11, 12].

Age of resource: The age of resource the cloud consumer rents.This means older resources lower price [11,12].

Cost maintenance: The amount of many that the service provider spends on maintaining and securing the cloud annually [11, 12]**.**

Service Customizability: How the service provider customize his services to meet the service user's requirements [11, 12].

3.3 Examples of Cloud Pricing Models.

The following subsection describes briefly some of the different techniques and models for Pricing in cloud computing.

Subscription Pricing Model: The price in the model is based on the subscription period this model is static, in this model the cloud user might sometimes overpay or underpay [13,14,18].

Pay –as-you-go Pricing Model: The price is set by the services provider and remains constantthis model is static; this model is unfair to customer because he might pay for more time than needed [13, 14, 18].

Competition –based Pricing Model: It is a dynamic model because the price depends on competition [13, 15, 17].

Value based Pricing Model: Service prices or resource based on the customer's point of view, it is a dynamic model [13, 16, 19].

Customer -based Pricing Model: It is a dynamic model; the cloud customers define the current price [13,17].

Cost –based Pricing Model: In this model the cloud provider specifies the profit level to set of resources and services, it is a dynamic model [13, 1, 22].

Genetic Model for Pricing in Cloud computing Market: It is a dynamic approach;the price is specified by cloud provider depending on the state of a real time market[13,1,21].
Hybrid Pricing Model: The price in this model changed according to the job queue wit times, it is fair to customers because of the price authority entity, which dynamically adjusts prices within a static limit, it is dynamic /static model [13, 1].

A novel financial Economic Model: In this model the cloud provider sets resources and services upper and lower boundaries, fair for both the service provider and the customers because the price is set in between upper and lower boundaries, it is a dynamic model [13,1].

Dynamic resource pricing on federated clouds: In this model the price could be determined depending on the level of supply and demand. However, this model does not support a good scalability during high demand period [15].

Pricing algorithm for cloud computing resources: That could be used for minimizing cost as well as maximizing profits for the service provider [16].

Datacenter net profit optimization with individual job deadlines: It is a dynamic model, cloud provider uses job scheduling mechanisms to set resource/services prices [20].

4. Comparison between Cloud Computing Pricing Models

Table2 shows a comparison among several cloud pricing models, considering the following criteria: the mechanism to determine the price, whether the model is static or dynamic, and the advantages and disadvantages, pricing approach , fairness , implementation.

Table 2: Pricing Model Comparison

Pricing Model	Type (Static/ Dynamic)	Approach	Fairness	Mechanism	Advantages	Disadvantages	Implementation
Subscription	Static	Price is based on the period of subscription.	Customermight sometimes overpay or underpay	Cloud provider defines Resource/ Service prices depending on lease period	It is good for consumer when Resources/ Services are utilized extensively	Consumer may pay more than the real utilization cost when he/she does not use Resources/ Services properly.	Implemented
Pay-as-you-go	Static	Price is set by the service provider and remains	Unfair to the customer because he might pay	Cloud provider determines a constant Resource/Service	Resources/ Services are available during reservation period,	Over provisioning and under provisioning problems may	Implemented

		constant.	for more time than needed	price	andthe price is known.	occur. The price is unchangeable.	
Pay-for-resources	Static	Cost-based	Fair for both Customersand theserviceprovider	Cloud provider determines Resource/Service pricesaccording to the cost.	Maximizes resource Utilization.	Difficult to beimplemented	Implemented
Dynamic resource pricing on federated clouds	Dynamic	Auction-based pricing	Fair for both customers and the service provider because the price is set according to the level of supply and demand.	Cloud provider usescurrent level of supply/demand todetermine Resource/Service prices.	Increases consumers' satisfaction and maximizes the numberof their profitablerequests.	It does not support a good scalability during high demand Period.	Theoretical approach with simulations
Value-based pricing	Dynamic	Prices setaccording to thevalue perceivedby the customer.	Fair toproducers where prices are set on the value perceived by the customer.	Resource/ Service pricesare defined depending on the customer's point ofview	Increases revenues	Difficult to be implemented	Implemented
Competition-based pricing	Dynamic	Price setaccording to competitors' prices	Fair tocustomers where prices are always set according to competitive prices	Cloud provider uses competitors' prices to determine the current price for service/ resource	Easy to implement	Ignores the cloudcustomers	Implemented
Datacenter net Profit optimization With individual job deadlines	Dynamic	Based on job scheduling	Biased toward the Service provider; it Mainly reduces costs and increases	Cloud provider uses job scheduling mechanisms to set Resource/ Serviceprices	Maximizes cloud provider's revenues, minimizes power consumption cost	It doesn't take in consideration the heterogeneous servers. Difficult to implement.	Theoretical approach with simulations
Genetic model for pricing incloud computing markets	Dynamic	Real-time pricing	Biased toward the Service provider; The algorithm considers increasing Revenues	Price is specified by cloudprovider depending on the state of a real time market.	Maximizes revenues, flexible implementation	Very critical duringthe (rise and fall) demand period.	Theoretical approach with simulations
A novel financial Economic model	Dynamic	Usage-based	Fair for both the service provider and the customer because the price is set between upper & lower boundaries	Cloud provider setsResource/Service pricesbetween upper and lower boundaries	Maximizes profits for cloud provider and improves QoS for cloud consumer	Maintenance costs are not taken in consideration.	Theoretical approach with simulations
Customer-based pricing	Dynamic	Price setaccording to what the customer is prepared to pay.	Fair to customers as customers are always taken into account	Cloud consumers definethe current price.	Cloud consumer is taken into consideration.	Difficult to set price	Implemented
Cost-based pricing	Dynamic	Price set by adding a profit element on top of the cost.	Not fair to customers where the perceived value of the product can be identified and apprehended by the customer after the price is set.	Resource/Service pricesare set according to the current market state.	It is better for cloud provider because it maximizes revenues by reducing cost.	Useless when supply/demand differquickly.	Implemented
Pricing algorithm for cloud computing Resources	Dynamic	Real-timepricing	Fair for provider because it reduces costs and maximizes revenues	Resource/Service pricesare set according to the current market state.	It is better for cloud provider because it maximizes revenues by reducing cost.	Useless when supply/demand differ quickly.	Theoretical approach with simulations
Hybrid pricing	Dynamic / Static	Price changed according to thejob queue	Fair tocustomers because of the price authority	Resource/Service prices are set according to the	Simple andhas low computational overhead.	Must reach an agreement on Common base	Implemented

		waittimes.	entity, which dynamically adjusts prices within static limits	current market state.		prices and Variation limits.	

5. Conclusion

In this paper, I have reviewed cloud computing key concepts and different types of cloud pricing models. We compared static pricing model versus dynamic pricing model. Based on this comparison, we conclude that on one hand the staticmodel is easy for both understand-ability and profit estimation but some problems such as under provisioning and over provisioning may occur. On the other hand the dynamic pricing model is fair for consumers because it supports them to pay depending on the QoS required; also it is fair for the provider so it help him to maximize profits. Also, I presented detailed comparison among thirteen pricing models based on the following aspects : the type static/dynamic),implementation, the mechanism to determine price, the advantages, and disadvantages.

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