Analysis of Demand Pricing Model in the Cloud Service Market

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Abstract. We adjust the charging price of cloud service market according to the user's behavior. As a means to adjust and optimize the allocation of market resources, the price adjustment based on the relationship between user demand and supply in the cloud market. In order to use cloud service resource reasonably and optimize the distribution of cloud service resource in the market, a pricing model based on demand is built.

Keywords: Cloud Services market · On demand pricing · Users

1 Introduction

With the rapid growth of cloud service users, cloud service market economic analysis and service pricing management become the focus of cloud service economic management. The charging price of cloud service market is the lever to adjust the behavior of cloud users, which affects the resource quantity of service market, it can be used as a means to adjust and optimize the allocation of market resources. From the economic point of view, we can regard the users in the cloud service market as the customers who buy goods in the market, and the market goods as cloud service resources. According to the relationship between user demand and supply in the cloud market, the price lever is used to adjust the relationship between user demand and supply of cloud service resources, finally, the cloud service resource can be used reasonably and the market cloud service resource allocation can be optimized.

Farrukh Shahzad et al. proposed that the existing service providers mainly adopt two typical pricing modes: Pay-per-use pricing and Subscription pricing [1]. Carlos Antunes et al. considered that the pricing strategies of cloud computing services can be divided into fixed pricing and Dynamic pricing, fixed pricing includes pre-set pricing and pay-for-use pricing. The author summarizes the service model and pricing model of a specific service provider through their cloud service products, and concludes that the pay-as-you-use pricing model is commonly used in IaaS and PaaS models, preorder pricing is commonly used in the SASS and IaaS models [2]. The above research lacks the model of pricing on demand according to the market situation. This paper makes up the blank of this research based on the present situation.

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2 Assumptions and Descriptions of the Problem

With the rapid increase of the number of users in the service market, the existing and potential users in the market are demanding more and more services from the cloud service market providers. The cost of operation and maintenance of cloud service market increases with the demand of users, which makes pricing management become an important content to improve the operation quality of cloud service market. At this point, the market demand is no longer to encourage users to enter, but to increase the market congestion control processing to ensure the quality of services to users, this also makes the contract-based billing approach not suitable for the needs of some users in the market to request billing. Therefore, in order to meet the needs of users, on-demand pricing strategy has been generated.

3 Demand Pricing Model

An on-demand pricing strategy is to charge for the amount of cloud service resources based on the actual needs of the user [3]. When the cloud services market determines the cost of using cloud service resources per unit of resources f_1, user I uses cloud service resources per unit of resources x_i, and the utility of user I is $u_i(x_i, Y, V) - x_i f_1$, where $u_i(x_i, Y, V)$, for user I gain utility, from the amount of cloud service resources per unit x_i. Then the utility of the service market is $u_i(x_i, Y, V) = f_1 X - C_Y - C_V$, where $X = \sum_{i=1}^{n} x_i$ is the total amount of service resources used by these N users in the market, the total amount of service resources provided by the market is Q, then the utilization rate of the market service resources $Y = \frac{X}{Q}$, $L = \sum_{i=1}^{n} l_i$ for the bandwidth of market service resources occupied by N users, the total resource bandwidth provided by the market is W, then the completion efficiency of the service tasks provided by the market is $V = \frac{L}{W}$, set at T time, to satisfy the cloud service resource usage of X, $L = \frac{X}{T}$ then $V = \frac{X}{TW}$.

For a given f_1, user I takes advantage of the set of feasible solutions x_i, that satisfy the corresponding: that is $x_i^{f_1} = \max_{x_i}[u_i(x_i, Y, V) - x_i f_1]$, at this point, the service resource usage of these N users $X^{f_1} = \sum_{i=1}^{n} x_i^{f_1}$ $i = 1, 2, ..., n$. The utilization of service resources $Y^{f_1} = \frac{X^{f_1}}{Q}$, the efficiency of services provided by the cloud market to users $V^{f_1} = \frac{X^{f_1}}{TW}$, the cloud market setting the price of its own Utility maximization problem $f_1^* = \max_{f_1}(f_1 X^{f_1} - C_{Y^{f_1}} - C_{V^{f_1}})$, and the cloud market setting the usage fees f_1^*, when the optimal service resource consumption of user I is satisfied, the total service resource consumption x_i'' of the n-bit user at this time is $x_i = x_i''$, $\frac{du_i}{dx_i} = f_1^*$. We set the utilization rate of the service resource X'', utilization of service resources Y'', and the completion efficiency of the service requirement task V''. The service resource consumption of user I under these two pricing strategies is compared, the service resource consumption under the on demand pricing strategy and the contract pricing strategy is compared. In the case of the contract pricing strategy $\frac{d^2 u_i}{dx_i^2} < 0$, when satisfied $x_i = x_i'$, in the case of the demand pricing strategy $\frac{du_i}{dx_i} = f_1^*$, when satisfied $x_i = x_i''$, according to the law of diminishing returns $\frac{d^2u_i}{dx_i^2} < 0$, that is to say $\frac{du_i}{dx_i}$, it is a subtraction function, and because $f_1^* > 0$, therefore $x_i' > x_i''$. Demand pricing strategy can reduce the use of market service resources more than contract pricing strategy, and $Y' < Y''$, $V' < V''$. Therefore, demand pricing strategy can control market congestion better than contract pricing strategy, thus through the price mechanism to regulate the purpose of market congestion.

4 Market Analysis

When user I selects the optimal amount of cloud service resources x_i in a completely monopolized cloud service market, he Utility maximization problem that $\frac{du_i}{dx_i} = f_1$, $i = 1, 2, 3, \ldots n$ in a completely monopolized market, the cloud service provider can completely control its own pricing f_1, according to the law of derivation $\frac{d\{f_1X - C_Y - C_V\}}{df_1} = 0$: Set market prices and pursue maximum self-interest, $f_1\frac{dX}{df_1} + X - \frac{C_Y'}{Q}\frac{dX}{df_1} - \frac{C_V'}{TW}\frac{dX}{df_1} = 0$, According to the law of derivatives: $du_i = f_1 dx_i$, $dx_i = \frac{1}{f_1}du_i$, $\frac{dx_i}{df_1} = \frac{1}{f_1}\frac{du_i}{df_1} = \frac{1}{\frac{du_i}{dx_i}\frac{df_1}{du_i}} = \frac{1}{\frac{d(\frac{du_i}{dx_i})}{du_i}\cdot\frac{du_i}{dx_i}} = \frac{1}{\frac{d^2u_i}{dx_i^2}}$ because $X = \sum_{i=1}^{n} x_i$,

$$f_1 = \frac{\frac{C_Y'}{Q}\sum_{i=1}^{n}\frac{1}{u_i''(x_i)} + \frac{C_V'}{TW}\sum_{i=1}^{n}\frac{1}{u_i''(x_i)} - \sum_{i=1}^{n}x_i}{\sum_{i=1}^{n}\frac{1}{u_i''(x_i)}} = \frac{\sum_{i=1}^{n}\frac{1}{u_i''(x_i)}\left(\frac{C_Y'}{Q} + \frac{C_V'}{TW}\right) - \sum_{i=1}^{n}x_i}{\sum_{i=1}^{n}\frac{1}{u_i''(x_i)}} = \left(\frac{C_Y'}{Q} + \frac{C_V'}{WT}\right) - \frac{\sum_{i=1}^{n}x_i}{\sum_{i=1}^{n}\frac{1}{u_i''(x_i)}}$$

, you can see that the pricing at this point is related to the operating costs of the service market, and to the $\frac{C_Y'}{Q} + \frac{C_V'}{WT}$, $u_i''(x_i)$ and $\sum_{i=1}^{n} x_i$ is related. If the market operation cost is bigger then the price will be higher, conversely, the price will be lower. The faster the marginal utility of the user decreases with the increase of usage, the lower the price will be, thus contributing to the increase of the utility of the user, and vice versa, the higher the price will be. If the market users use the higher the price will be higher, conversely, the lower the price.

If competitive factors are introduced into the market, competition will lead to the service provider's unit cost f_1 of service resources in the cloud service market, and continuously reduce. Assuming that there are two different price sums in the market f_{1^a} and f_{1^b}, let's say that after the cloud service provider sets the price $f_{1^a} < f_{1^b}$, user I Utility maximization problem, follow $\frac{du_i}{dx_i} = f_1^*$, choose your own optimal service resource consumption sum under different prices x_i^a and x_i^b, according to $\frac{d^2u_i}{dx_i^2} < 0$, we know $x_i^a > x_i^b$, the utility of user I at this point is respectively sum $u_i(x_i^a, Y, V) - x_i^a f_1^a$ and $u_i(x_i^b, Y, V) - x_i^b f_1^b$

$$u_i(x_i^a, Y, V) - x_i^a f_1^a - [u_i(x_i^b, Y, V) - x_i^b f_1^b]$$

$$u_i(x_i^a, Y, V) - u_i(x_i^b, Y, V) - f_1^a(x_i^a - x_i^b)$$

$$u_i'(\xi)(x_i^a - x_i^b) - f_1^a(x_i^a - x_i^b) = (u_i'(\xi) - f_1^a)(x_i^a - x_i^b)$$

One of them is Lagrange's Theorem, $u_i(x_i^a, Y, V) - u_i(x_i^b, Y, V) = u_i'(\xi)(x_i^a - x_i^b)$, Among them $u'_{(\xi)}$ is $\frac{du_i}{dx_i}$, when $x_i = \xi$ is $x_i^b < \xi < x_i^a$, Coalesced $\frac{d^2u_i}{dx_i^2} < 0$, So $u_i'(\xi) > u_i'(a) = f_1^a$, $u_i'(\xi)(x_i^a - x_i^b) - f_1^a(x_i^a - x_i^b) = (u_i'(\xi) - f_1^a)(x_i^a - x_i^b) > 0$, that is, $u_i(x_i^a, Y, V) - f_1^a x_i^a - [u_i(x_i^b, Y, V) - f_1^a x_i^b] > 0$, $u_i(x_i^a, Y, V) - f_1^a x_i^a > u_i(x_i^b, Y, V) - f_1^a x_i^b > u_i(x_i^b, Y, V) - f_1^b x_i^b$

Therefore, it can be seen that after the introduction of competitive factors, with the price reduction, the utility of user I gradually increased.

5 Conclusion

In the cloud service commodity market, cloud service resource providers price the resources they provide and charge consumers based on the amount of resources they consume. In order to adapt to the influence of market supply and demand on the price dynamics of service resources, the price of service resources is determined by various parameters in the scheduling process. If the number of consumers of a cloud service resource increases, the price of the commodity will be appropriately raised, and conversely, the price will be appropriately lowered, and the price fluctuation will be based on the balance of supply and demand.

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