Cost Model for Software as a Service

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***Abstract*— The SaaS model is software delivery model that allow the end user to use the software online without it being installed on their computer. The end user is charged by the service provider for using the services. Most of the existing Cloud cost models determine usage-charges based on infrastructure cost. In this paper, the cost model for the SaaS services is proposed that focuses not only on infrastructure but also on service parameters. The proposed model considers the service parameter for the SaaS such as customization, configurability, portability, security, QoS parameters including performance, usability, response timeliness, scalability and reliability, interoperability, data isolation and application isolation. With the help of proposed model, the service provider is able to calculate the efforts in developing the service more accurately and provide better service package deals to the service consumer.**

Keywords— cloud computing; Software as a Service; cost model; pricing

I. INTRODUCTION

SaaS model is known for its simple deployment method, lower expenses for customer, flexible to allow many customers with single software. SaaS is accessed through web browser and charges are based on subscription of yearly or monthly. It is different from the traditional softwares in which the customers have to buy a license for the software and to do all maintenance and installation by them. SaaS is significantly advantageous to the customers. It frees the customers from hardware, implementation, maintenance, installation costs in order to run the application on customers' side. SaaS vendors generally charge their applications through subscription pricing. Based upon some parameters the service providers charge their customers. The other cost models that might be used by providers include effort based pricing, packaged and server based licensing, software renting, pay-per-use, utility based charging, revenue sharing with partners, freemium and advertisement-based models [1][2]. SaaS model is best suitable for the condition wherein the user doesn't wish or is unable to run the application on his system.

Consider a situation where in an organization has reliant entities—such as authorized retailers or resellers—with which it, by adopting a SaaS Model, the organization will benefit as the SaaS will deliver a better IT process automation and information transfer. This results in revenue to the SaaS provider by the organization. This case leads us to the question "How much the payment should be?". Payment should be such which benefits both the End-User as well as the Service Provider. Payment is the cost plus the remuneration of the service provider. The next question then arises is "How to assess the cost?". Most of the existing Cloud cost models mainly predict cost focusing only on IaaS cost and as there is no separate cost model for SaaS, the SaaS providers are forced to use the existing Cloud cost model for predicting cost for their services and the Cloud cost model is unable to acknowledge and accommodate costs all the efforts made in developing the SaaS service. Therefore, a cost model is needed that would mainly focus on parameters related to SaaS services. These parameters may be configurability, customization, QoS parameters such as scalability, availability, usability, response timeliness and performance, portability, total cost of ownership and return on investment.

The section 2 discusses the different cost models of cloud computing and section 3 presents the proposed model for SaaS service. In the section 4 the results and analysis of proposed approach are discussed and section 5 concludes the whole paper.

II. RELATED WORK

The cost model determines what will service provider get from customer for providing services. The pricing can be fixed or dynamic. The fixed pricing charges the customer the same amount all the time whereas the dynamic pricing charges the customer amount that changes dynamically or it is market dependent, where the charges is based on real time market conditions[3].

In order to calculate the cost, the factors that affect the cost need to be discovered. These factors can be hardware, power and cooling infrastructure, software licensing, hardware and software maintenance, network bandwidth requirements, memory, storage, processing power usage, usage duration, allocation capacity, training, etc[4]

Different service providers apply different strategies or models for finding the cost. The most commonly used model is pay-as-you-go model [5] in which customers are charged with fixed price per unit. Many leading enterprises such as Amazon, Google App Engine and Windows Azure implement pay-as-you-go model. For SaaS pricing, the subscription based cost model [6] is widely used. The users are charged periodically for the services provided. Although, it does not

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determine cost according to what was being used by user.

Many theoretical studies have been introduced in cloud computing for calculating the cost. A genetic algorithm for pricing was proposed that handles the problem of competitive price offers in service negotiations in the cloud computing markets. In this approach, suitable price is evolved from a pricing function. This approach results in selecting the flexible provider in unpredictable market rather than the rigid provider [7].

The cost model was given that determine the TCO(total cost of ownership) for a cloud computing services[8]. The cost factors and its related cost type discovered form the basis for calculating cost. The different cost factors that were identified were strategic decision, selection of cloud computing services and cloud types; evaluation and selection of service provider; service charge for IaaS, PaaS, SaaS; implementation, configuration, integration and migration; support; initial and permanent training; maintenance and modification; system failure; backsourcing and discarding.

Amazon EC2 provides three different pricing models to customer: Reserved Instances, Spot Instances, On-Demand Instances [9].Reserved Instance charges low amount that is paid once and offers significant discount on hourly charge for that instance. Spot Instance allows the customers to bid for unused capacity. The spot instances are charged with the spot price which is laid by Amazon. This price fluctuates based upon the demand and supply of the spot instance. On-demand instance allow the customer to pay a fixed amount by hour with no commitments or upfront payments. The customers are free from cost of planning, purchasing and maintaining.

The cost model was proposed for cloud computing services that models multistage game with the cloud service provider who provide both reserved service and interruptible spot service [10]. The reserved service guarantees quality and is purchased at fixed price in the beginning. Whereas the spot service is can be interrupted by provider and has the price dynamic adjustment. The model is build that uses mix strategy of reserved service and spot service.

The cost model [11] for resources applies financial option theory to calculate the cost for the cloud computing commodities. The lower bound on the cost is given by finance model and upper bound is by compounded-Moores law. The model considers five parameters and maps them to BSM (Black-Scholes-Merton) Model to price the cloud resource. The five parameters are initial investment, contract time, Rate of depreciation, quality of service and age of resources.

Cloud option pricing [12] uses financial option theory to mitigate risk and minimize the cost for the customers. The concept of option pricing scheme is to value an option, one must form a self-financing hedging strategy that replicates the pay-off of the option. Through an option holder can exercise the option and investor pays to purchase an option contract.

With the tiered pricing the services can be offered in many tiers [13]. Every tier provides fixed computing and SLA with fixed price per unit. This type of pricing is adopted by Amazon cloud systems

Most of the existing Cloud cost models mainly predict cost focusing only on IaaS cost and as there is no separate cost model for SaaS, Therefore, a cost model is needed that would mainly focus on parameters related to SaaS services.

III. Proposed approach

The preliminary assumption for the SaaS cost model construction is that the infrastructure is already available for service deployment. In order to predict the cost, firstly we need to determine the different factors considered by provider or customer. These are as follows:

- Infrastructure required to deploy the service
- QoS parameters such as service availability, performance, usability, response timeliness, reliability and scalability.
- Configurability of the service is the aspect that allow user to configure any of following options such as user interface, data, organizational structure, workflow and business logic.
- Customization of the service allow customer to make changes to the service. The changes may be done to the functions or look or feel of the service. Some provider do not provide customizable SaaS, the user can only utilize the service.
- Security including data security, network security, application security and management security.
- Interoperatability that is the ability of the service to integrate the other information, such as information stored at other service provider, with the local information.
- Application isolation is whether the application is isolated by single instance-single user, multi instance, multi instance-multi user and virtualized SaaS.
- Data isolation is ability of service to isolate the data of the customer. The data isolation can be provided by dedicated database, shared database, and shared schema.
- Software fault tolerance
- SLA is service agreement between customer and service provider. It can include service definitions, duties of customer, performance measurement, help desk response time for various problems and so on.
- Portability is ability to migrate customer's data from one provider to another without any problem.
- TCO(total cost of ownership) includes license fee, support fee and user training fee
- ROI (return on investment) is benefits to provider in investment.

The above factors are grouped to form different cost types. The different cost types and its related factors are given in table 1

TABLE I. COST TYPES AND ITS RELATED COST FACTORS

Cost types	Cost factors
IaaS Cost(i)	Total investment of infrastructure(inf)
QoS(Q)	Quality variables(β),Service charges(p)
Storage cost(st)	Usage cost(u), variable cost(var)

IaaS cost: IaaS cost is the amount that service provider charges for the total investment in setting up the infrastructure for providing the service. The price can be the existing infrastructure or the leased infrastructure.
QoS cost: The QoS cost is amount charged for the service that is being provided by the provider. The QoS cost is that the provider charges for quality parameters of the service. The cost factors such as QoS parameters, customization, configuration, portability, interoperatability, data isolation, application isolation and security forms the QoS cost.
Storage Cost: The provider charges the user for its storage space.

A. Basic Mathematical Modeling of Cost types:
For mathematical modeling of the cost, suppose cost type $z \in Z$ is subject to set $T=\{i,Q,s\}$ and the cost factor $v \in V$ is subject to set $V=\{inf,p,u,var\}$. The different cost types can be determined as

Total investment of infrastructure: The cost factor the total investment of infrastructure inf determines the IaaS cost. The service provider can charge the user very small percent of its total investment. The IaaS cost C_i is given by

$$C_i = x\% \text{ of } inf \quad (1)$$

Where x is the percentage that is specified by service provider and inf is the total investment of the service provider in laying the infrastructure for providing and deploying the services.

Quality variables: The various performance and quality cost factors such as security metrics, QoS metrics and software quality metrics can determine the QoS cost. These metrics can include customer, application, data and network security, service availability, usability, performance, response timeliness, SLA management, configurable UI, data and business logic of SaaS service, data isolation, and application isolation at virtualized SaaS. For performance based services and the economical based services the QoS cost is calculated differently. If the user opt for performance based service then the QoS cost is given by

$$C_Q = \sum_{i=1}^{n}(\beta_1 + \beta_2 + \cdots + \beta_n) * p \quad (2)$$

Where $ß_i$ the quality variables are whose values are according to the quality parameters such as accuracy, response time, and security etc; n is the number of quality parameters and p is the service charges.
For economical based services, no quality parameters are considered which only provides basic function of SaaS services. This basic level of SaaS meets the following metrics:

- All basic features of SaaS services including network security and management security.
- Multi-tenancy
- Service is non-configurable.

The QoS cost can be given as

$$C_Q = \beta * p \quad (3)$$

Where β the service constant and p is the service charges
Usage cost: The usage cost is the actual amount which is charged for the actual use of the storage. The usage cost C_u is given by

$$C_u = C_{base} + S_u * P_u \quad (4)$$

Where C_{base} is the base price, S_u is the actual storage space used and P_u is the usage price.

Variable Cost: The variable cost is the additional charges for excess part. If the storage space used is greater than the maximum storage space then there are charges for the excess storage space. The variable cost is given by

$$C_{var} = P_{var} * r \quad (5)$$

Where P_{var} is the variable price and r is the difference in actual measured storage space and maximum storage space (in GB).

The Usage cost and the variable cost when sum up together form the storage cost. Hence is given as

$$C_{st} = C_u + C_{var} \quad (6)$$

The sum of IaaS cost, QoS cost and storage cost form the total cost given as

$$C_{tot} = C_i + C_Q + C_s \quad (7)$$

The discount can be given to users based on the ideal time period. Also compensation cost is subtracted when there is not satisfactory service delivery. So the cost for these customers comes out to be

$$C_{tot} = C_i + C_Q + C_{st} - C_d - C_f \quad (8)$$

Where C_d is discount price and C_f is compensation price

One option for pricing schemes for SaaS is divided into categories on the basis of the quality metrics of service.

1. *Basic SaaS*: This scheme provides all the basic features of SaaS. The following features are provided:
   - Service offered is multi-tenant.
   - Network security and management security is provided.
   - Service can be non-configurable or only UI is configurable.
   - Data is isolated through dedicated database.
   - Application is isolated through single instance – single user or multi instance.

2. *Standard SaaS*: The following features are provided in addition with basic SaaS features
   - QoS parameters such as scalability, usability, availability, performance, response timeliness.
   - Service level agreement contract can be made between customer and service provider.
   - The user can configure UI and data.
   - Data security is provided.
   - Data is isolated through dedicated database or shared schema.
   - Application is isolated through multi-instance or multi instance- multi user.

3. *Optimized SaaS*: Optimized SaaS scheme provide following features in addition with standard SaaS features:
   - Application security is provided.
   - Fault tolerance software is provided.
   - Service with configurable UI, data and business logic is provided.
   - Data isolated through shared schema.
   - Application is isolated through multi instance – multi-user.

4. *Integrated SaaS*: Along with optimised features, it provide the following features:
   - Service can be customized.
   - Service with fully configurable including UI, data, business logic and workflow is offered.
   - Portability is provided.
   - Collaboration and sharing of information with other providers.
   - Data isolated through shared schema.
   - Application is isolated through virtualized SaaS.

B. *Proposed Algorithm*

Input: S_u actual storage space, performance based service or economical based service.

Output: Total Cost

i. Calculate IaaS cost C_i

$$C_i = \frac{x}{100} * T$$

ii. Calculate QoS cost

a. If performance based service then do

$$C_Q = \sum_{i=1}^{n} (\beta_1 + \beta_2 + \cdots + \beta_n) * p$$

b. If economical service then do

$$C_Q = \beta * p$$

iii. Calculate storage cost

a. Calculate usage cost

$$C_u = C_{base} + S_u * P_u$$

If actual storage space is greater than maximum storage then

b. Calculate variable cost

$$C_f = P_f * r$$

c. Calculate storage cost

$$C_s = C_u + C_f$$

iv. Calculate total cost

$$C_{tot} = C_i + C_Q + C_s$$

IV. Results and Analysis

The proposed cost model is implemented by developing a cost forecasting tool. A service provider planning for delivering a SaaS service can estimate the total cost owned by him through the forecasting tool.

The cost distribution of different type of service is illustrated in figure showing the bar graph shown in figure 1 and the pie chart shown in figure 2. Table 2 shows the different type of service.

TABLE II. Types of Service

Type of service	**Cases**
Economical based service	1
Standard Service	2
Optimized Service	3
Integrated service	4

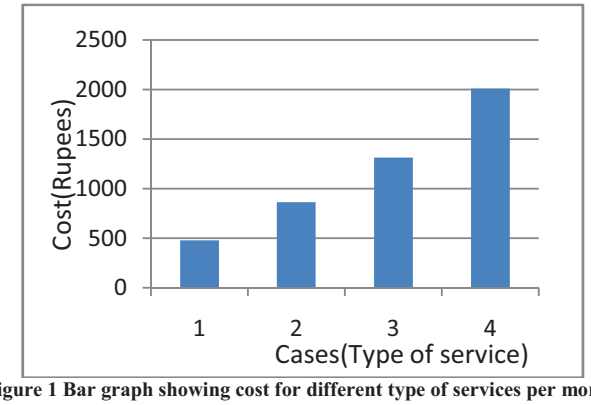

Figure 1 Bar graph showing cost for different type of services per month

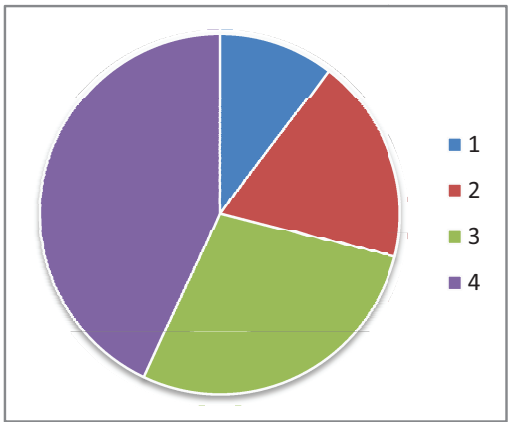

Figure 2 Pie chart showing cost distribution of type of service per month

A. Effect of Cost factors on Cost:

The standard services are assumed for evaluating the effect of different parameters. The red line in the graphs shows the total cost variation and blue line show different parameters.

Performance: The graph showed in figure 3 shows the effect of performance factor on the total cost. The total cost increases with the increase in the performance factor.

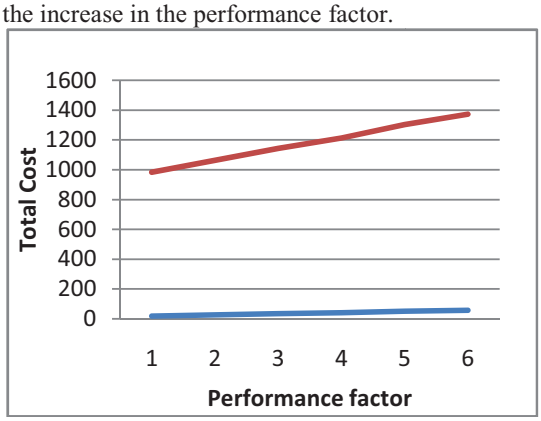

Figure 3 Effect of performance on total cost

Scalability: The graph has shown in figure 4 that shows the effect of scalability factor on the total cost. The total cost increases with the increase in the scalability factor.

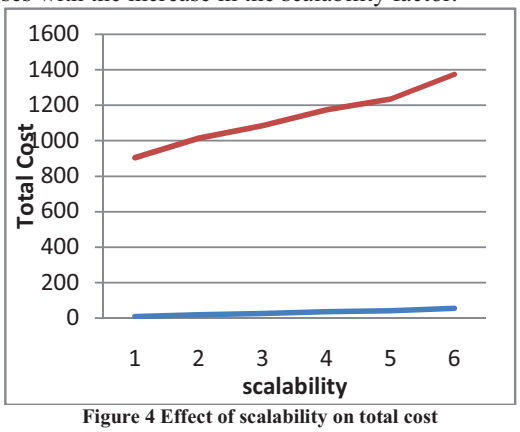

Figure 4 Effect of scalability on total cost

Availability: The graph has shown in figure 5 that shows the effect of availability factor on the total cost. The total cost increases with the increase in the availability factor.

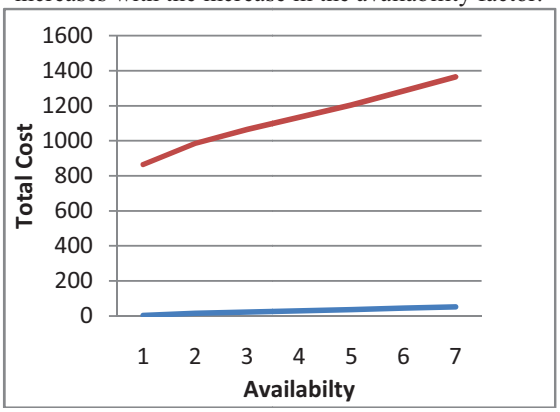

Figure 5 Effect of availabilty on Total Cost

Response timeliness: The graph has shown in figure 6 that shows the effect of response timeliness factor on the total cost. The total cost increases with the increase in the response timeliness factor.

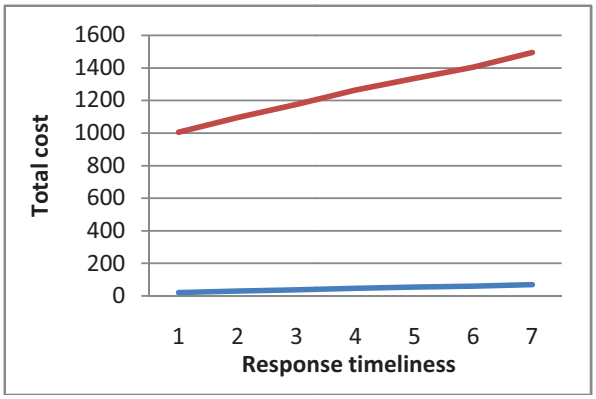

Figure 6 Effect of Response timeliness on total Cost

Data security: The graph showed in figure 7 shows the effect of data security factor on the total cost. The total cost increases with the increase in the data security factor.

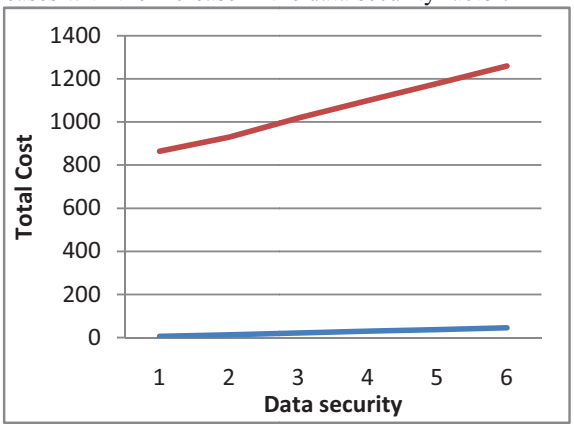

Figure 7 Effect of data security on Total Cost

V. Conclusion

In this paper, the cost model has been proposed to predict the cost for the SaaS services. The cost model proposed calculates the total cost based on the cost factors for the SaaS services. These cost factors are the factors which are associated with different parameters of the SaaS and add-up to give us the total cost for the SaaS service. Such factors include infrastructure, configurability, customization, QoS parameters such as scalability, availability, usability, response timeliness and performance, portability, total cost of ownership and return on investment. These factors characterize the SaaS services. The proposed approach provides following benefits

- The effort is calculated effectively.
- SaaS service provider will be able to price its service as per consumer's requirement in form of various service packages.
- Using proposed model, service provider can easily append features in existing service and able to calculate the additional effort without recalculating the entire cost of application.

The proposed model can be further extended by adding more service related parameters. Also, the proposed cost model can be made dynamic by considering market related factors such as demand and supply.

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