A Novel Trust Model for Selection of Cloud Service Provider

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***Abstract*—In this article we have proposed a model which will help the Cloud Service Users (CSUs) in finding out the efficient and trustworthy Cloud Service Provider (CSP) on the basis of data taken from regulatory authorities, performance of CSP in last one year and feedbacks taken from the customers. Moreover, the proposed model is flexible enough to be customized according to the precedence level of parameters for the CSUs. The key needs and most preferred demands of users regarding quality of service are kept in consideration during the development of this trust model at service layer of cloud computing. Although, there is no such model exists to evaluate the performance efficiency of CSP and the trust building of CSUs over the CSP available in the literature so far. Yet, we have tried to give a comparative analysis of proposed model with general existing model to portray the importance and requirement of the designed model.**

Keywords—trust model; cloud service provider; cloud service user; down time; up time; fault tolerance; application update frequency

I. INTRODUCTION

In cloud computing, the services are provided over the network by managing the available resources whether they are hardware or software. Users can create or customize the environment according to their needs since this is one of the facilities provided to them by cloud computing. User who wants to use any service on cloud need to have specific application installed on his/her mobile, computer or PDA to access that specific service available on cloud network through internet connection. The cloud computing provides shared resources, including data storage space, networks, specialized corporate and user applications. The services of cloud computing are using the resources in term of hardware, databases, application across the vendor over the internet. This is widely known as "as a service". The Service layer of Cloud Computing can be further divided into three more sub-layers. The three sub layers are Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) [1]. Infrastructure as a Service is a model in which an organization outsources the equipment used to support operations including storage, hardware, servers and networking components.

The service provider owns the equipment and is responsible for housing, running and maintaining it. The client typically pays on a per-use basis. In Platform as a Service (PaaS), users can develop their own applications. For the runtime environment of the application, solution stacks and entire computing platforms are offered by the platform as a service provider. In Software as a Service (SaaS), different vendors or service providers host the applications and those applications are made available to the customers by using the internet. Fig. 1 shows these three service layers of cloud computing with their potential applications.

Although, cloud computing has gained a remarkable progress but there are some weak areas as well with respect to its performance i.e. return-on-investment, market churn, privacy, possible downtime, security issues, cost, inflexibility and lack of support etc. [2]. These issues have their precedence level with respect to the organization that is getting benefit from cloud service. In this article, we are proposing a trust model for the selection of CSP since there are a lot of CSPs in the market and each has its own proficiency in specific type of services. Due to the tight competition among the CSPs, the CSPs must provide the required services to the CSUs to their demanded level. Although, a range of criteria parameters are there for the selection of cloud service provider, yet, the ultimate selection of the CSP is based on the preferences that the user is interested to choose in the management of its system. Following attributes needs to be considered while selecting trustworthy CSP.

Security measures: The CSP must guarantee to the trustor that the assets would be in safe hands and never be misused.

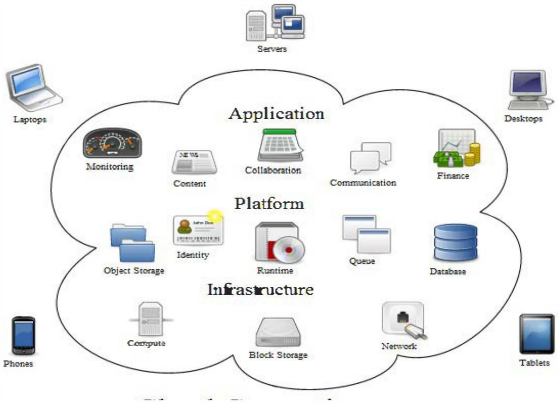

Figure 1: Service Layer of Cloud Computing

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Compliance with regulatory body's standards: Regulatory bodies define different standards to keep things in the organization up-to-date. So a CSP organization that is in compliance to the standards of the regulatory body is and should be preferred by the clients.

Down time: The time for which services are unavailable to the service user. The downtime should be minimized and if there arises a need to the CSP to get the system down for an upgrade, repair or maintenance then that should preferably be pre-planned.

Up time: The time of the year when the services of the CSP is available to the users. The trustor prefers the cloud service provider that offers the best up time in the year with respect to its efficient availability to the users.

Customer support: When the customer is in need of the service, support or help from the CSP then it should be given in a proper way to resolve the issue of client and to satisfy him.

Performance of a Specific Service: If the organization is providing the services regarding any specific service then it is generally renowned in the market for that service. So, that CSP is generally be preferred to be selected.

Latency (Response time): A CSP that has the minimum time in response to complaint, request or query is preferred to be the choice as the cloud service provider organization.

Among the aforementioned seven most important parameters, some are preferred by one type of CSUs and some are preferred by other type of CSUs. Hence, each has its own importance with respect to its implementation scenario.

We are hereby introducing our model that best fit for the assessment of trustworthy cloud provider for the user. After deep analysis of users' needs and requirements, we come up with the new model that appends weight to the attributes. Our model provides an option to user to evaluate various available CSPs based on their reputation in market on the behalf of their provided QoS and selects the most trustworthy CSP. Our analysis further concludes that the selection of "quality of service" as the prioritize parameter compared to security measurements is more suitable for most of the people. So, our focus is on availability of service and to minimize the downtime.

Rest of the paper is organized as follows. Previous work is given in section II. A proposed solution is presented in detail in section III. Conclusion, acknowledgement and references are given in the subsequent sections.

II. Previous Work

First, Huanan Liu et al [3] worked on the analysis and design of trusted computing applied into cloud. They state that one of the biggest problems faced by computer technology is data security issues and it's getting more and more serious as time going on. Their proposed model of trusted computing added two new modules.

- Service Authentication List Management (SAL)
- Configuration Dynamic Update Module (CUM)

The core discussion in this paper is directly concerned with identity authentication and access control. The proposed model applied for trusted computing into cloud environment is designed as follows.

The identities of the virtual machines which are involved in the model should be authenticated. In case of large system and for some special services, the model may need more than one Virtual Machine (VM). There can be many reasons such as malfunctioning or disaster that some specific virtual machine is no longer working or providing the services. So there should be the submission of this service to the configuration update module to take over all the existing working. This CUM (Configuration Update Module) receives this application and immediately selects a new VM. This replaces the old one and start working. This CUM submits the amended information to the service authentication list management. At the end, this service authentication list updates the identity information. In the concluding remarks, this paper depicts the advantages and disadvantages of trusted computing and describes the improvements for addressing the challenges and uncertainties seen by trusted computing.

Mary-Jane Sule [4] discussed the deployment of data centers in the educational institutes. He stated that it has some major concerns. This paper presented a work on deployment strategy of cloud infrastructure in higher educational institutes; deployment should be as a community cloud named as CIaaS framework. The provision of opportunity is to share the resources and to collaborate in work together. Such framework of community cloud is most feasible for better service in educational institutes.

Hui et al. [5] introduced a well-defined service in educational institute. E-Learning environment in educational institutes for distance learning that opens the opportunity for researchers to work around. By considering the "Google collaborative platform" as a case study in E-learning environment, it provides the platform for collaborative learning platform.

Feng Xiaona et al. [6] presented their work on application of cloud computing in university library user service model. Problems relating to the application of cloud computing in libraries, problems are discussed and solved in this research article. Here the authors proposed public cloud among many university libraries that can converse library resources. It can also be the source of user satisfaction those are interested to use the library resources.

Subsequent section presents the trust model for the selection of service provider among the available CSPs.

III. Proposed Solution

The core attributes at which we focused are down time, up time, customer support, fault tolerance capability and latency. Down time is the time duration when service is not available (users could not access the cloud). The proposed model includes high precedence to the service provider that have minimum down time history during last one year. So CSP with minimum down time should be selected. Uptime clearly defines maximum time when services are available. Efficiency of any cloud service provider can be determined from its up

time, especially when designing the model for most of the people who want uptime on high priority. So a CSP with good efficiency should be selected. Value of customer support experience accomplishes big importance to trust upon the cloud service provider. A CSP with better ranking in customer support should be selected. Fault occurrence can happen in any network service where multiple devices constantly work together but all service providers must have their back plans, either battery banks or generators for power back up and data connectivity with other online servers for data backup. So a CSP with alternate power plans and back up facilities should be selected.

The detailed description of these evaluation parameters are discussed in subsequent paragraphs.

A. Down Time

The proposed model calculates the downtime of available service providers for last one year (data taken from regulatory authorities). We counted the number of times service was down during last one year due to some known and unknown reasons. We named them as planned and unplanned outage respectively. Planned outages are those outages which are planned before the outage and users have information of that outage in advance. Unplanned outages are those outages which are unexpected and users are not aware of those outages before their occurrence. Similarly, outage timings are divided into Peak Hours and Off-peak Hours. Peak hours are those hours in which demands for services are very high.

For raw data, we sum up all planned outages that came in the peak hours and in case of compiled data, user can simply enter the sum of planned outages in peak hours. We divided the assigned weight by the sum of all planned outages in peak hours. Number of planned outages in peak hours is represented by "A". Mathematical modeling of the said description is given below:

Equation given below is used to calculate the number of planned peak hours downtimes entered by the user.

$$\boldsymbol{A = \sum_{i=1}^{n} D_{pph(i)}} \quad (1)$$

In case value of "A" gets equal to zero then the maximum points i.e. 1 is assigned to **P**lanned **O**utage **P**eak Hour Downtime (**POP**). Otherwise points for POP are measured through the following equation.

{

If, A = 0

Then, POP = 1

Else, $\boldsymbol{POP = \frac{1}{A} 0.2}$

}

For raw data, we sum up all planned outages that came in the off-peak hours and in case of compiled data, user can simply enter the sum of planned outages in off-peak hours. We divided the assigned weight by the sum of all planned outages in off-peak hours. Number of planned outages in off-peak hours is represented by "B". Mathematical modeling of the said description is given below:

Equation given below is used to calculate the number of planned off-peak hours downtimes entered by the user.

$$\boldsymbol{B = \sum_{i=1}^{n} D_{poh(i)}} \quad (2)$$

In case value of "B" gets equal to zero then the maximum points i.e. 1 is assigned to **P**lanned **O**utage **O**ff-peak Hour Downtime (**POO**). Otherwise points for POO are measured through the following equation.

{

If, B = 0

Then, POO = 1

Else, $\boldsymbol{POO = \frac{1}{B} 0.9}$

}

For raw data, we sum up all unplanned outages that came in the peak hours and in case of compiled data, user can simply enter the sum of unplanned outages in peak hours. We divided the assigned weight by the sum of all unplanned outages in peak hours. Number of unplanned outages in peak hours is represented by "C". Mathematical modeling of the said description is given below:

Equation given below is used to calculate the number of unplanned peak hours downtimes entered by the user.

$$\boldsymbol{C = \sum_{i=1}^{n} D_{uph(i)}} \quad (3)$$

In case value of "C" gets equal to zero then the maximum points i.e. 1 is assigned to **U**nplanned **O**utage **P**eak Hour Downtime (**UOP**). Otherwise points for UOP are measured through the following equation.

{

If, C = 0

Then, UOP = 1

Else, $\boldsymbol{UOP = \frac{1}{C} 0.1}$

}

For raw data, we sum up all unplanned outages that came in the off-peak hours and in case of compiled data, user can simply enter the sum of unplanned outages in off-peak hours. We divided the assigned weight by the sum of all unplanned outages in off-peak hours. Number of unplanned outages in off-peak hours is represented by "D". Equation (4) is used to calculate the number of unplanned off-peak hours downtimes entered by the user.

$$\boldsymbol{D = \sum_{i=1}^{n} D_{uoh(i)}} \quad (4)$$

In case value of "D" gets equal to zero then the maximum points i.e. 1 is assigned to **U**nplanned **O**utage **O**ff-peak Hour Downtime (**UOO**). Otherwise points for UOO are measured through the following equation.

{

If, D = 0

Then, UOO = 1

Else, $\boldsymbol{UOO = \frac{1}{D} 0.5}$

}

Marks for any CSP with respect to its down time are calculated using the equation given below.

$$\boldsymbol{D_T = (POP + POO + UOP + UOO)/4} \quad (5)$$

Maximum point which can be assigned to any CSP using (5) is 1.

B. Uptime

Uptime clearly defines maximum time when services are available. Efficiency of any CSP can be determined from its up time.

We are picking up only 50 random days because it is very difficult to enter all values for 365 days of a year.

$$\boldsymbol{UT = \frac{TA}{24}} \quad (6)$$

Equation given above clearly shows the uptime points. We have selected 50 random days in a year and checked that how many maximum hours' services were available. Maximum point which can be assigned to any CSP using above equation is 1.

C. Fault Tolerance Capability

There are many types of faults which can be faced by a system. Sometimes these faults can directly affect the services that are being provided by the CSP. Any interruption in the services is not tolerable, so we also focused on the "Alternate power Plans" (APP) to ensure the availability of services. Other thing which we also considered in this regard is "back-up facility" (BUF), where FP = APP + BUF.

We will calculate the number of failures occurred while backup plans were implemented for last one year.

$$\boldsymbol{FTC = \frac{FP}{20}} \quad (7)$$

Maximum point which can be assigned to any CSP using above equation is 1.

D. Customer Support Experience

Value of customer support experience (CSE) accomplishes big importance to trust upon the CSP. We added points to the quality of customer support provided by the CSP on the behalf of customer's experience. Efficiency in creating, managing and updating application as per the needs of customers directly affects the customer's experience. Similarly when a customer faces some problem or asks for information when required, the dealing of CSP with the customer affects the customer support experience. The response time of CSP to any complaint by the user also add towards the CSE. The best experience is awarded highest points i.e. 5 and worst experience is given lowest points i.e. 0. We get the feedback for last one year which is done after each quarter of the year.

$$\boldsymbol{CSE = \frac{TM}{50}} \quad (8)$$

Where TM = Total Marks and

$$\boldsymbol{TM = 1 * MQ1 + 2 * MQ2 + 3 * MQ3 + 4 * MQ4} \quad (9)$$

'1' is the weight (multiplier) for 1st Quarter

'2' is the weight (multiplier) for 2nd Quarter

'3' is the weight (multiplier) for 3rd Quarter

'4' is the weight (multiplier) for 4th Quarter

Hence, total points (TP) that can be awarded to a CSP are 50 by using (9). Maximum point which can be assigned to any CSP using (8) is 1.

E. Application Update Frequency

One of the most important features of the service provided to the user is the availability of the updated applications or software. As per SLA (Service Level Agreement), we inspect how frequently cloud service provider provides us the updated application on the server. Marks are awarded based on the frequency of update that is categorized into 5 time spans i.e. weekly, monthly, 3 monthly, 6 monthly, 9 monthly and annually where weekly updates are assigned maximum points i.e. 5 and annually updates are assigned minimum points.

$$\boldsymbol{AUF = \frac{UP}{5}} \quad (10)$$

Maximum point which can be assigned to any CSP using above equation is 1.

F. Final Calculation

We have left few choices to the customer to select the CSP on the basis of his/her requirements. So we added weights to all the five parameters which a user can change according to his/her requirement. For example, if a customer is more interested in customer support experience then the customer / user can change the weights assigned to that parameter. Higher the weight assigned, higher will be the role of that specific parameter in the selection of CSP. Cloud service provider with the highest points will be selected for cloud service.

$$\boldsymbol{Total\ Points =} \quad (11)$$

$$\boldsymbol{J \times DT + K \times UT + L \times FTC + M \times CSE + N \times AUF}$$

Where, value of J, K, L, M & N may range from 1 to 10 but this is the choice for user to select the value according to their preferences.

G. Sample Calculation

In **Table 1** given below, column named "Values" shows the values of the parameters that the CSP is awarded based on calculation given in subsections of section IV. Column "Weight" shows the values assigned to the related parameter according to their precedence level or required priority to the customer or user.

From (11)

$$Total\ Points = 0.9 \times 9 + 0.9 \times 10 + 0.8 \times 8 + 1 \times 6 + 0.6 \times 7$$

$$Total\ Points = 8.1 + 9.0 + 6.4 + 6 + 4.2$$

$$Total\ Points = 33.7$$

In the same way all the other CSPs' points are calculated.

Figure 2 shows the main window of developed application for cloud computing trust model at service layer for educational institutes.

IV. Comparative Analysis

The exact and targetable solution does not exist in the literature for the said purpose. The main focus of existing models is based on security parameters and the back up plans in case of system crash. Solutions provided so far are expensive as compared to our proposed model because service providers should have to spend a lot to implement security features and secure back up plans. But in most cases cloud operators hire third party services to implement the security features as per the requirements of an organization, finally additional cost added to the consumers.

Table 1: Table Showing the Summarized View of all the Parameters of Proposed Solution with its Final Calculation Format

Evaluation Parameter	Values	Weight
Down Time	0.9	9
Up Time	0.9	10
Fault Tolerance Capability	0.8	8
Customer Support Experience	1	6
Application Update Frequency	0.6	7

Figure 2: Main Window of developed application for the said model in C#

S. Mehbub et al. [7] discussed the selection of trustworthy cloud provider only based on its SLA and conclude that selection criteria on SLA is not convincing. Their proposed architecture is a multi-faceted trust management system for a cloud marketplace, providing means to efficiently differentiate between good and poor quality providers. This system opens an opportunity for the customers to obtain the trust score by customizing the attributes. Problems diagnosis in the previous work is violation in SLA and lack of transparency. Also cloud providers are not willing to share audit reports with any organization. More-over incomplete information, information available at unreliable sources, incomplete knowledge about architecture of system or services are the key problem in previously designed Trust models. Attributes those are considered by the author are security, latency, availability, and customer support. Proposed model is designed to provide the customize solution, attributes that is best suitable for any of the organization can be used as per requirements.

Our model proves high efficiency in selection of trust worthy cloud service provider in terms of cost, service quality, frequent update and fault tolerance capability as compared to the above comparative model. Since after detailed workout on the needs and requirements of educational institutes, we diagnosed that cost can be reduced by excluding the extra features of security from the requirements and the additional secure back up plans.

Table 2 clearly depicts the difference between the existing model and the proposed model with respect to the cost effectiveness, quality of service, security features, delay in service and the back-up features. Based on these parameters we have come up with a conclusion about the priority of the proposed solution over the existing solution mentioned in [7].

V. Conclusion

After the complete study and detailed analysis of the proposed idea, we have come to an agreed conclusion that the proposed model is the best and cheapest way to find out the most appropriate service provider according to the requirements of the user. The proposed solution evaluates cloud service providers in terms of services they are offering and quality of service as well. The key performance evaluation parameters considered in this context are service down-time, service up-time, customer service experience, fault tolerance and application up-date frequency. These aforementioned five parameters are the proven attributes for any could service provider in order to provide the quality services to the user. The most differentiable feature of our proposed solution is its customized and flexible approach. The user can prioritize the most appealing and required parameter over the other parameters. One can set the precedence level for the solution

Table 2: Comparative Analysis of Proposed Model with Existing Model based on Various Performance Parameters

	Existing Model [7]	Proposed Model
Cost Effective	No	Yes
Quality of Service	Medium	High
Security Features	High	Medium
Delay in Service	Medium	High
Backup Features	Medium	High

parameters according to his/her requirements by just giving the highest weight to the highly precedent parameter and the lowest weight to the least important parameter.

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