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A cost-effective delay model for leased data centers to establish private cloud computing services

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Abstract : *Nowadays, using of cloud computing services and developing movement towards on-demand and inexpensive communication and storage infrastructures, and also specialized software is one of the main topics for discussions among manufacturers, enterprises, universities and research centers in developing countries. However, the main challenge is that the information system based on public cloud computing is too expensive to establish for small and medium scale organizations. In this paper, an approximated delay model has been proposed by utilizing the K dedicated servers in leased data centers as a K M/M/1 delay model in order to establish a cost-effective cloud computing system. Subsequently, it has been shown that in the cloud computing system developed based on the proposed delay model, the establishment cost of the system is noticeably reduced as well as the security and customer service performance is improved.*

Keywords -*PaaS, SaaS, IaaS , cloud computing, private cloud, public cloud, delay model.*

I. INTRODUCTION

These days using of cloud computing services and developing movement towards the inexpensive communication and storage infrastructures, and also specialized software is one of the main concerns among producers, commercial companies, universities and research centers in developing countries. However, the forward challenge in public cloud services is the organizations' concerns regarding information security and privacy issues [1] in one hand, and high costs of such system establishment on the other hand. Meanwhile, the new technologies such as Quantum Computer [2], DNA computers [3] and so on, have not been reached to industrial standard yet. Origination the ERP in the beginning made a revolution in software engineering. Nevertheless, the companies were less interested purchasing for ERP because of some reasons such as high price of ERP, long time consuming for system analysis, obstacles on the way of system optimization, localization issues and etc. [4]. In such a situation, Portal origination having some distinct features was so desirable [5] such that the web portals were assumed an appropriate approach to implement e-commerce [6]. However, portal can be never taken the place of the ERP. Hence, ability of creating a desirable information system is approximately unreachable so far. In actual fact, the problem is that the software deployment phase is not the end of the software development life cycle. Since in deployment phase making an effective and inexpensive infrastructure has been received a great importance from the point of view of both customers and business owners. Here, the question is that how it is possible to develop such a system which provides an infrastructure such that it fulfills both customer and business owner needs? In this paper, a delay model for leased data centers has been proposed in order to establish a cost-effective cloud computing system.

i. CLOUD COMPUTING AND DATA CENTERS

The importance and the main issues of cloud computing was presented in a conference held in 2013 in San Francisco by the IT industry owners and sellers of cloud computing services [7]. Cloud computing has a simple definition. Cloud computing is a kind of computing using the Internet such that a collection of resources including software, platforms and information are provided upon the customer demands. In actual fact, cloud computing services are mostly an ideology for providing desirable responding on customer demands. The cloud services can be classified in three folds as mentioned bellow.

1. SAAS (SOFTWARE AS A SERVICE) MODEL

SaaS comprises the remote software services in a shared form. For example, expensive multi-user original software can be presented to the customers within a specified time interval in a lower price. On the other hand, business owners don't need an extra payment for buying licensed applications, making a platform, maintenance services charges and startup costs.

2. PAAS (PLATFORMS AS A SERVICE) MODEL

PaaS encompasses the platform services in a shared form. Such services can contain the database servers, web servers, operating systems, or run-time environments. For example, the both Oracle and Windows Azure clouds offer the Database-as-a-Platform.

3. IAAS (INFRASTRUCTURE AS A SERVICE)

Iaas involves infrastructure services in a shared form. According to a period of time agreement, IaaS services can provide any kinds of network hardware such as: routers, load balancers, VLANs, any types of application servers, or a collection of costly mass storage media, such as SSDs.

ii. FOUR-LAYER MODEL FOR A CLOUD COMPUTING SYSTEM

Responding to the aforementioned demands for a system implementation based on public cloud computing system, organizations and enterprises face to considerable expenses. Fig.1 demonstrates a four-layer model for a cloud computing system [8][9].

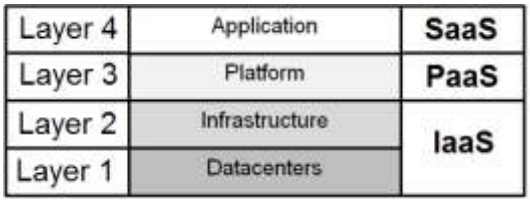

FIG 1.Four-layer model based on cloud computing system [8][9]

1. THE FIRST LAYER (DATACENTERS)

A system based on cloud computing usually uses one or more data centers. Data centers are expensive structures in both maintenance service charges and Equipment costs. A data center can contains more than hundred servers, backup servers, many connection switches and stack ones, many storage devices such as: SSD, and safety technologies such as: RAID, UPS, power generators, firefighting devices, smoke alarms, environmental sensors, etc.

2. THE SECOND LAYER (INFRASTRUCTURES)

This layer consists of a collection of virtual machines that can be exploited fulfilling the customer demands.

3. THE THIRD LAYER (PLATFORM)

This layer providers a run-time environment for cloud-based applications.

4. THE FOURTH LAYER (APPLICATION)

This layer is for running applications and providing their results.

II. PROPOSED DELAY MODEL

Obviously, such anaforementioned system for small and medium organizations and businesses is too expensive to establish. One solution for this problem is using of leased data centers for private cloud systems. In such a system, it is possible to establish several private cloud systems by sharing dedicated or leased data centers. In this paper, a cost-effective delay model is proposed in order to implement several private cloud systems based on shared leased data centers. A data center with two by two distinct K servers with an approximately infinite queue waiting is given. A model for this kind of data center can be the M/M/K delay model. However, considering the security policies and performance considerations, it is possible to dedicate each server in data center to each business owner. In such situation, the delay model M/M/K can be applied as K model of M/M/1 (Fig.2).

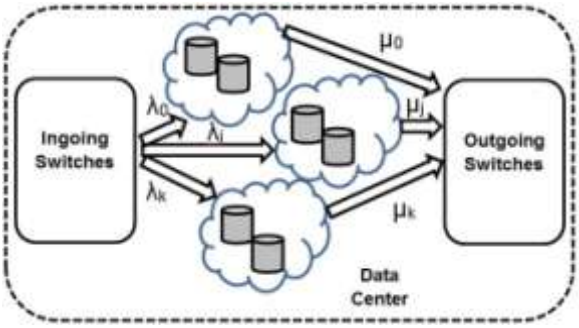

FIG2. The proposed delay model using K private clouds to provide a cost-effective cloud system.

According to Fig.2, regardless of the delay time for ingoing and outgoing switches in the data center, let λ_j be the customer arrival time and μ_j be cloud service time both for the jth private cloud. Here, based on M/M/1 delay model, the random variable λ_j has the Poisson distribution, while the interval distribution between $t(n+1)_j$ and tn_j for the private cloud jth, $\tau_{n_j} = t_{n+1_j} - t_{n_j}$, has the exponential distribution. The probability of the absence of customer demands for the service in time interval $R_k \leq \tau_{n_j}$ is equal to:

$$\textbf{(1): } P\left\{\tau_{n_j} \leq R_j\right\} = 1 - e^{-\lambda_j R_j}$$

Also, according to the delay model M/M/1, obviously, the random variable μj has the exponential distribution, so the probability of cloud service time within the duration of $S_{n_j} \leq S_j$ is equal to:

$$\textbf{(2): } P\left\{S_{n_j} \leq S_j\right\} = 1 - e^{-\mu_j S_j}$$

Based on the exponential distribution, we are dealing with a none memory system, means that the time duration of customer waiting queue, related to private cloud j, is independent of ingoing time and remaining time for the service providing by the private cloud j. Therefore, in the proposed model, the Markov theory can be exploited. Thus, the number of customers in a private cloud can be considered as a continuous random process depends on Markov chain. Now, supposing n as the number of present customers in private cloud, the state diagram for the proposed model is as presented in Fig.3.

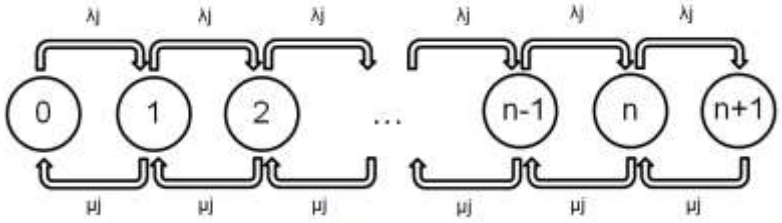

FIG3. State diagram for the proposed model.

Fig.3 illustrates the probability of transmission from state n to state n+1, so:

$$\textbf{(3):} \lambda_j P_n = \mu_j P_{n+1}$$

Where Pn is the probability of customer n available in private cloud j in a stable state, so we have:

$$\textbf{(4):} P_n = \lim_{t\to\infty} P\{N_j(t) = n\}$$

Therefore, considering the coefficient factor ρ_j in cloud j as $\rho_j = \frac{\lambda_j}{\mu_j}$, the equation (3) can be written as equation (5):

$$\textbf{(5):} P_n = \rho_j P_{n-1} \quad ; n = 0, 1, \ldots$$

As: $\sum_{n=0}^{\infty} P_n = 1 = \rho_j^n P_0$, so equation (5) can be written as below:

(6): $\boldsymbol{P_n = (1 - \rho_j)\rho_j^n}$

Now, the average number of available customers in cloud j in a stable condition can be expressed as below:

(7): $\mathbf{N_j = \frac{\rho_j}{1-\rho_j}}$

Finally, using the Little theorem, $N = \lambda T$, and the fact that $T = \frac{N}{\lambda}$, the average delay of service time for customers in cloud j, Tj, can be obtained as below:

(8): $\mathbf{T_j = \frac{1}{\mu_j(1-\rho_j)}}$

III. CONCLUSION

Establishment of an information system based on public cloud computing is so expensive for the organizations and business owners. In this paper, a model based on leased data centers has been proposed for establishing cost-effective private cloud systems. In this model, a delay model has been proposed for cloud computing systems, considering the efficiency and security issues. In the proposed model, a delay model M/M/K has been estimated by K delay model M/M/1. Subsequently, the average number of customers and the average delay of service time for customers have been obtained for each private cloud.

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