A User Demand Uncertainty based Approach for Cloud Resource Management

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Abstract – **In this paper, we attempt to investigate about how to deal with events stated by uncertainty demand in cloud computing environment between Software as a Service provider, Software as a User and cloud resources provider. The variation considers the supply and demand of resources. The events on uncertainty demand ensure provisioning resources and prevent fluctuation demand. We propose to create resource negotiation and use Fuzzy Optimization for demand fluctuation. This result is relation to the event on uncertainty demand in cloud. The issue is to model the uncertainties on demand to warranty quality of service.**

1. Introduction

Cloud computing is a resource delivery and usage model to get resource via network. They has wake up wide research interest and has been fulfilled by industry. Cloud computing can be divided into three categories: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).

Arfeen, et al. [1] provide new service will face more traffic intensity and delay sensitiveness in future. Medernach and Sanlaville [2] suggested that requests of each user arrive at following times. Chaisiri, et al. [3] stated that on-demand and reservation cost for long and short-term provisioning. We define that cloud computing is more involved between customers and provider related to ensure resource provisioning. The expectation from customer to utilize the product make the provider must guarantee the availability whatever customers required. The additional charge is considerable to be avoided. Zimmermann [4] declared that uncertainty is considered which has various causes and affected by input and output information. The deficiency or abundance of information is related to available and required information.

Li and Ierapetritou [5] said that uncertainty in process came from many aspects, such as demand order, batch or tool failures, variability time and resource changes. The scheduling objective could cover minimizing the time for completing the tasks. Carlsson and Fullér [6] stated that undesired event is related to risk probability. An expected value will be benefit for outcome. In cloud computing, resource provider offers resources and services based on Service Level Agreements. For executing job, ensuring resource allocation model against expected node failures.

Walker, et al. [7] divided uncertainty into three parts for decision model support; place, equal and landscape. They decided to make a model formulation. Different view about uncertainty supposed to provide information for supporting strategy decisions.

The main goal for this research is deciding optimal resource allocation based on uncertainty demand. The rest of this paper is organized as follows. Section 2 describes uncertainty demand on resource allocation in cloud. In section 3, we discuss about dealing with the event, fuzzy theory and to support resource negotiation on uncertainty demand. In section 4, we discuss related work. Section 5 contains discussion with model experiment. Section 6 consists of some simulation and Section 7 we conclude and do for future work.

2. Uncertainty Demand on Resource Allocation in Cloud

Some cloud computing providers adopt the utility computing model. They will charge for using resources based on usage. The services have long been referred to Software as a Service (SaaS). Defining resource allocation is commonly bound up with limited resources so as to reach the best outcome. In cloud computing, there are two things related to resources; computing resources and storage resources. Uncertainty in resource demands express that occasionally is not likely for cloud providers to fulfil all the requests. Fluctuating demand may get up from client taste or resource provisioning. Failure to properly demand fluctuations may cause unsatisfied customer and lead to loss. Providers could be very supple to manage this situation. Strategy for resource allocation enables SaaS provider and cloud resource provider to arrange their supply and demand. When customers send requests for utilizing offered by SaaS provider, cloud resource provider process this thing to satisfy the customer's request. Borgonovo [8] stated that arrangement in uncertainty is unique experiment for many trials of valuation problem. Analysing on uncertainty demand could be obtained from decision-making view. Carlsson and Fullér [6] stated that growing request on computing power and engineering encouraging the positioning of high

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performance computing. In cloud, Zhang [9] studied about single cloud provider and answer the inquiry about how to fit supply and price for customer request to capitalize on the provider's income and customer satisfaction while decreasing cost of energy. This research is implemented to Iaas provider.

Jain and Deshmukh [10] planned tools by using fuzzy hybrid negotiation. Not only help customer and provider but discover new choices and analyse resource controls in particular schedule.

Walker, et al. [7] stated that any uncertainty that can be labelled sufficiently in statistical description. The most evident of statistical uncertainty is the size uncertainty related with all data. Using the scenario is an approach to bargain with uncertainty associated with outside situation and its belongings on the system. Model uncertainty is connected with both the theoretical model and consists of two fields: structure uncertainty and technical uncertainty. Structure uncertainty ascends from less of enough understanding of the system. It will be influenced by among variables. For example: equations, assumptions and mathematical models. Technical uncertainty is affected by software or hardware errors.

3. Fuzzy Set Theory, Fuzzy Numbers and Resource Negotiation

Zadeh [11] introduced fuzzy set theory to deal in mathematical model for uncertainties. This theory has been developed and implemented in real application. Fuzzy numbers are used to mathematically represent linguistic values. Fuzzy numbers can have different form for different application or different engineering systems.

3.1. Fuzzy Sets

Let X be a collection of object universe whose elements are denoted by X. A fuzzy subset A in X is characterized by its membership function $\mu_A(x)$. This function associates with every single element x in X in the interval $[0,1]$.

$$\mu_A : X \to [0,1] \to \mu_A(X) \in [0,1]. \quad (1)$$

The value of the membership function $\mu_A(x)$ represents the membership grade of x in X. A closer the value to 1 is, the stronger the degree of membership of x in A is. Some basic notions that are defined for fuzzy sets are union, intersection and complementation.

$$\mu_{A\cup B}(x) = \max(\mu_A(X), \mu_B(X)) = \mu_A(X) \vee \mu_B(X) \quad (2)$$

$$\mu_{A\cap B}(x) = \min(\mu_A(X), \mu_B(X)) = \mu_A(X) \wedge \mu_B(X) \quad (3)$$

$$\mu_{A^{C}(X)} = 1 - \mu_A(x) \quad (4)$$

3.2. Fuzzy Numbers

Fuzzy numbers are used to mathematically represent linguistic values. Fuzzy numbers can have different form for different application or different engineering system.

Dubois and Prade [12] stated that a fuzzy number A is a subset of real line R whose membership function $\mu_A(x)$ can be a continuously mapping from R into a closed interval [0,1]. The membership function $\mu_A(x)$ has the following characteristic.

(a) $\mu_A(x) = 0$, for all $x \in (-\infty, a]$;
(b) $\mu_A(x)$ is strictly increasing on $[a, b]$;
(c) $\mu_A(x) = 1$, for all $x \in [b, c]$;
(d) $\mu_A(x)$ is strictly decreasing on $[c, d]$;
(e) $\mu_A(x) = 0$, for all $x \in [d, \infty)$,

where a, b, c and d are real numbers. In a special case, fuzzy number may have $a = -\infty, or\ a = b, or\ b = c, or\ c = d, or\ d = +\infty$.

Purba, et al. [13] declared that is supposed that A is convex and bounded, except it is exactly detailed in a definite condition and application. A fuzzy number A can be expressed as follows.

$$\mu_A(x) = \begin{cases} \mu_A^L(x), & a \le x \le b \\ 1, & b \le x \le c \\ \mu_A^R(x), & c \le x \le d \\ 0, & otherwise \end{cases}$$

Triangular and trapezoidal fuzzy numbers have been commonly applied in several engineering systems.

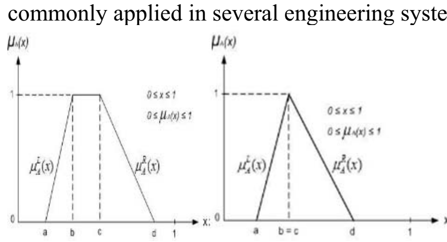

Fig.1.Trapezoidal and triangular fuzzy number

Türkşen and Zarandi [14] argued the benefit of system fuzzy approach in real-world applications to relate fuzzy model in supply chains; with the flexibility, accepting of imprecise data, practically simple to realize.

3.3. Resource Negotiation

Pruitt [15] stated that negotiation is a method by which collection of objects attempt and wake up to an equally tolerable settlement on some problem. Sim [16] disclose that the strategy about cloud cooperation of customer, broker agents and provider agents in cloud markets. In cloud business model, there is an event that necessary possibility for providing the resources. The influence of uncertainty demand needs dealing between consumer and provider. Cloud resources must ensure flexible supply and demand. Customer can choose the provider fulfil their resource requirements. Li [17] suggested the optimal of resource provisioning algorithm. The interaction is among SaaS user, SaaS provider and cloud resource provider. Supporting for this research, An, et al. [18] divided six protocol for negotiation; offer, accept, bid, confirm, cancel and decommit. Meanwhile, Rubinstein [19] assume strategic approach about bargaining situation. Two participants are dealing on partition of a pie. Every participant, in order deals a partition and his opponent may approve to the offer "Y" or reject it "N". Receiving of the offer finishes the dealing. Later rejection, the rejecting participant has to create a counter offer and so on. Legally, let S = [0,1]. A partition of the pie is identified with a number s. Let s_1 be the percentage of the pie that participant accept in the partition s: that is = s and $s_2 = 1 – s$.

Using the other method, Teng and Magoulès [20] proposed a new Bayesian Nash Equilibrium Allocation algorithm to explain resource management problem in cloud. Johansson and Sternad [21] included probability distribution for problem solving to optimize resource tasks in the existence of uncertainty for mobile communications. They offered a process for allocating resources to maximize system throughput.

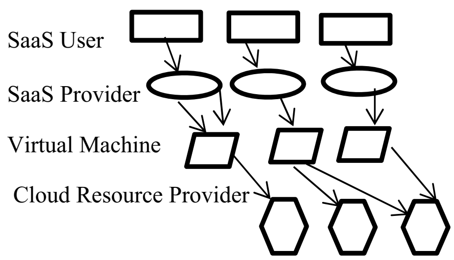

Fig.2. Roles in cloud computing

Cloud resource provider is consists of CPU, RAM and bandwidth.

4. Related Work

Li [17] offered an efficient resource provisioning approach. The SaaS providers purpose to decrease the payment of using virtual machine from cloud provider and warranty meeting Quality of Service necessities for the SaaS users.

Sim [16] introduced the design of cloud negotiation that maintenances activities in cloud market resources. He proposed the way is considered to provision the many-sided between customers and brokers, and the other is about broker and resource provider to gain a group of resources to create a service for sub-leasing for clients.

Klir and Yuan [23] wrote that to understand about the values given to the components of the general set fall within a detailed sort and show the membership rank of their components in the set. Several fuzzy represent the concepts of linguistic concepts for example low, medium, high so on are often engaged to explain condition of an adaptable.

5. Model Experiment

The other researcher offered the concepts of bargaining model, Dhingra and Rao [22] assumed there, exists a convex, bounded and closed set of alternatives S, a different thing $X_w \in S$ relation with the point no bargain between the players, and a set of utility functions $U_i(X)$, i = 1,…..,k, related with each player. To decide a reasonable result, a dealing function $B(X)$ is defined as

$$B(X) = \prod_{i=1}^{k} [U_i(X) - U_i(X_w)]$$

for all $X \in S^* \subset S$, where

$$S^* = [X | X \in S, U_i(X) - U_i(X_w) \geq 0]$$

An optimum bargaining solution X^{opt} is defined as

$$B(X^{opt}) = \max B(X), \;\; X \in S^*$$

$\max B + a\lambda$

Where B

$$B = \prod_{i=1}^{ncf} [F_{iu} - f_i]$$

We set up the mathematical model:

C_p^{cpu}= capacity of CPU of cloud provider p

C_p^{ram}=capacity of memory of cloud provider p

C_p^{net}= capacity of bandwidth of cloud provider p

VM_{pq}^{cpu}= CPU of cloud resource p required by a VM for SaaS provider q

VM_{pq}^{ram}= memory of cloud resource p required by a VM for SaaS provider q

VM_{pq}^{net}= network bandwidth of cloud resource p required by a VM for SaaS provider q

S_o^{cpu}= computation service of o th SaaS provider

S_o^{ram}= storage service of o th SaaS provider

S_o^{net}= transmission service of o th SaaS provider

U_o^{cpu}= computation service of o th SaaS user

U_o^{ram}= storage service of o th SaaS user

U_o^{net}= transmission service of o th SaaS user

The formulation model is determined by B function.

$$B_{cloud} = \left(C_p^{cpu} - \sum_q VM_{pq}^{cpu} \right) + \left(C_p^{ram} - \sum_q VM_{pq}^{ram} \right) + \left(C_p^{net} - \sum_q VM_{pq}^{net} \right)$$

Subject to: $S_o^{cpu} \geq U_o^{cpu}$; $S_o^{ram} \geq U_o^{ram}$; $S_o^{net} \geq U_o^{net}$

Consider three fuzzy set that represent the events of low demand, medium demand and high demand. The total numbers of SaaS Provider is 100 and SaaS User is 80. The membership function is stated on the interval [0,100] and [0,80] as follows:

$$\mu_1(x) = \begin{cases} 1, & C_p^{cpu} \geq VM_{pq}^{cpu} \\ C_p^{cpu} - \sum_q VM_{pq}^{cpu}, & 0 \leq VM_{pq}^{cpu} \leq C_p^{cpu} \leq 1 \\ 0, & C_p^{cpu} \leq VM_{pq}^{cpu} \end{cases}$$

$$\mu_2(x) = \begin{cases} 1, & C_p^{ram} \geq VM_{pq}^{ram} \\ C_p^{ram} - \sum_q VM_{pq}^{ram}, & 0 \leq VM_{pq}^{ram} \leq C_p^{ram} \leq 1 \\ 0, & C_p^{ram} \leq VM_{pq}^{ram} \end{cases}$$

$$\mu_3(x) = \begin{cases} 1, & C_p^{net} \geq VM_{pq}^{net} \\ C_p^{net} - \sum_q VM_{pq}^{net}, & 0 \leq VM_{pq}^{net} \leq C_p^{net} \leq 1 \\ 0, & C_p^{net} \leq VM_{pq}^{net} \end{cases}$$

An optimal approach will be considered the parameters influence output uncertainty.

6. Simulation

The model described related to computation, storage and transmission service. We try to combine the process from SaaS Provider and SaaS User with the capacity of CPU, memory and bandwidth.
Algorithm: SaaS provider – cloud resource provider – SaaS User

Step 1:
Calculate the maximum $C_p^{cpu} - \sum_q VM_{pq}^{cpu} + C_p^{ram} - \sum_q VM_{pq}^{ram} + C_p^{net} - \sum_q VM_{pq}^{net}$.
Step 2:
Cloud resource provider compute if $S_o^{cpu} \geq VM_{pq}^{cpu}$; $S_o^{ram} \geq VM_{pq}^{ram}$; $S_o^{net} \geq VM_{pq}^{net}$.
Step 3:
[Input1]
Name='CPU'
Range=[0 100]
NumMFs=3
MF1='Small':'trimf'MF2='Medium':'trimf'
MF3='Big':'trimf'
[Input2]
Name='Memory'
Range=[0 100]
NumMFs=3
MF1='Small':'trimf'MF2='Medium':'trimf'
MF3='Big':'trimf'
[Input3]
Name='Bandwidth'
Range=[0 100]
NumMFs=3
MF1='Small':'trimf'MF2='Medium':'trimf'
MF3='Big':'trimf'
[Output1]
Name='Computation'
Range=[0 100]
NumMFs=3
MF1='Low':'trimf' MF2='Medium':'trimf'
MF3='High':'trimf'
[Output2]
Name='Storage'
Range=[0 100]
NumMFs=3
MF1='Low':'trimf'MF2='Medium':'trimf'
MF3='High':'trimf'
[Output3]
Name='Transmission'
Range=[0 100]
NumMFs=3
MF1='Low':'trimf'MF2='Medium':'trimf'
MF3='High':'trimf'
Step 4:
Send to SaaS user if $U_o^{cpu} \leq VM_{pq}^{cpu}$; $U_o^{ram} \leq VM_{pq}^{ram}$; $U_o^{net} \leq VM_{pq}^{net}$.
Step 5:
[Input1]
Name='Computation_Service'
Range=[0 80]
NumMFs=3
MF1='Low':'trimf'MF2='Medium':'trimf'
MF3='High':'trimf'
[Input2]
Name='Storage_Service'
Range=[0 80]
NumMFs=3
MF1='Low':'trimf'MF2='Medium':'trimf'
MF3='High':'trimf'
[Input3]
Name='Transmission_Service'
Range=[0 80]
NumMFs=3
MF1='Low':'trimf'MF2='Medium':'trimf'
MF3='High':'trimf'
[Output1]
Name='CPU_User'
Range=[0 80]
NumMFs=3
MF1='Small':'trimf'MF2='Medium':'trimf'
MF3='Big':'trimf'
[Output2]
Name='Memory_User'
Range=[0 80]
NumMFs=3
MF1='Small':'trimf'MF2='Medium':'trimf'
MF3='Big':'trimf'
[Output3]
Name='Bandwidth_User'
Range=[0 80]
NumMFs=3
MF1='Small':'trimf'MF2='Medium':'trimf'
MF3='Big':'trimf'

This is the result of experiment:

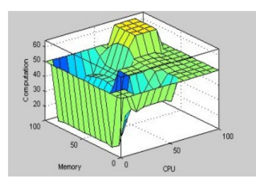
Fig.3.CPU-Memory on Comp

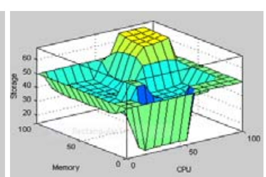
Fig.4.CPU-Memory on Storage

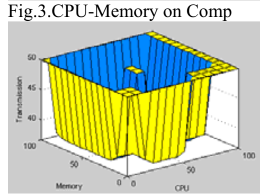
Fig.5.CPU-Memory on Trans

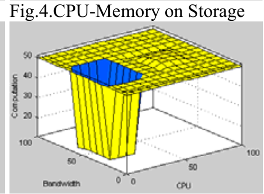
Fig.6.CPU-Bandwidth on Comp

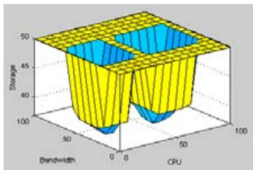

Fig.7.CPU-Band on Storage

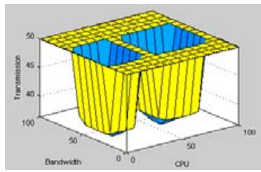

Fig.8.CPU-Band on Transmission

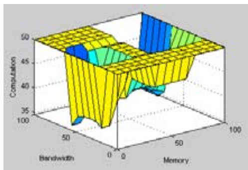

Fig.9. Memory-Bandw on Comp

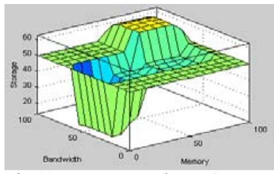

Fig.10.Memory-Bandw on Storage

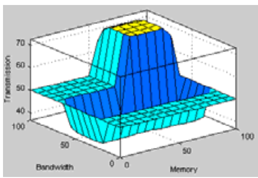

Fig.11. Memory-Band on Trans

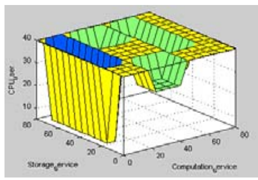

Fig.12. Comp-Storage on CPU

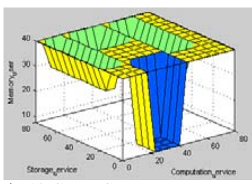

Fig.13.Comp-Storage on Memory

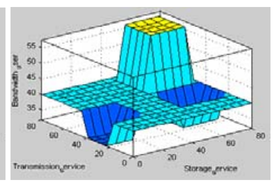

Fig.14.Storage-Tran on Bandwidth

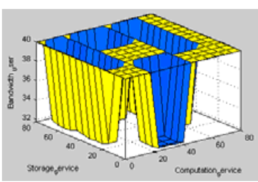

Fig.15. Comp-Tran on Bandwidth

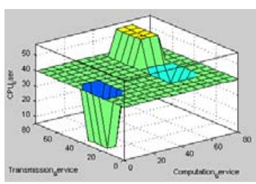

Fig.16.Comp-Tran on CPU

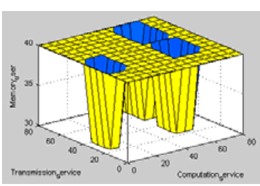

Fig.17. Comp-Tran on Memory

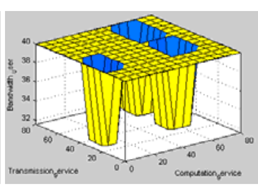

Fig.18.Comp-Tran on Bandwidth

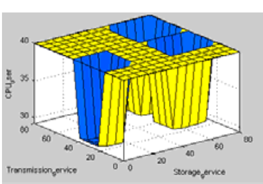

Fig.19.Storage-Tran on CPU

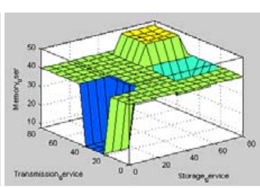

Fig.20.Storage-Tran on Memory

In this paper, we propose about resource negotiation between SaaS Provider, SaaS User and Cloud Resource Provider. We test on a simulation between computation, storage, and transmission on SaaS Provider. In the process of computation and storage and transmission, there is some alternative bargaining on low, medium and high demand. CPU, memory and bandwidth have the important job to supply the request from SaaS Provider. We categorize three things for input and ensure every output correlated with input. The optimal value for the process on SaaS Provider is available at CPU-memory on computation and storage and memory-bandwidth on storage and transmission. There is some opportunity for CPU user, memory user and bandwidth user for receiving service for what they request. The optimal value for the process on SaaS User is available at storage service-transmission service on memory user and bandwidth user then computation service-transmission service on CPU user.

7. Conclusion and Future Work

A new approach model for uncertainty demand based on the concept of fuzzy optimization is presented. The method approach yields a cooperative model of CPU, memory and bandwidth on SaaS Provider and computation, storage and transmission service on SaaS User. It will help decision making for warranty quality of service. Future work, we will investigate on an efficient strategy for design problem by uncertainty. We will offer the model of resource negotiation to evaluate efficiency of the proposed methodology.

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