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Fuzzy Mathematical Model for Resource Allocation in Cloud Computing Environment

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Abstract— In this work, the mathematical modelling of the resource allocation using fuzzy logic techniques is done. The embodiment of the fuzzy logic in the scheduler in case of infrastructure as a service Cloud model is shown here. The Cloud lease scheduler several times comes under the situation, where the dynamic load conditions are available. Although the resources are available in the scattered parts, which not providing any tricks to make provision to satisfy the pending request from the Customer. The Administrator can take certain decision from available resources, like some primary memory available on one node, and plenty of CPU cycles are available on another node and so on. Similarly the logical resources could be available for creation of the Virtualized resources and provision of the software as a service or platform as a service. Different membership functions are useful to solve different tricky situations in resources allocation in IaaS Clouds.

Keywords— Mathematical model, fuzzy logic, Cloud Computing, lease scheduler.

I. INTRODUCTION

The lease scheduler like Haizea[18] introduced various lease processing tactics, which can be plugged and played with the OpenNebula Clouds. This work attempts to introduce the fuzzy based scheduling into the lease scheduling for IaaS Cloud. The very clear and energy efficient Cloud lease scheduling schemes are introduced in Desktop Cloud [17]. This work is not emphasizing on the discussion of using either on different styles of virtualization, but irrespective of that, trying to introduce the fuzzy membership functions like generalized bell shape, sigmoid, singleton, piecewise linear. The results of the Triangle and trapezoidal are not discussed here, because already discussed in one of the previous work.

It is possible to obtain the different values of the resource allocation chances using the different membership functions. We have used the testing methodology to get the values of the allocation chances, which will be useful to feed to the decision making in the scheduling. The overlapping values of the English terms in the form of Graphical methods have been shown in this method. We can get some better witty solutions to our problem statements.

Here we are adding the set of fuzzy logic techniques also know as possibility theory for Cloud lease scheduling. The inexact and vague values of the data can be represented using the fuzzy logic system. The Fuzzy logic allows "fuzzy" thresholds or boundaries to define for each category. Fuzzy logic is alternative to two value logic and probability theory. The degree of membership in the range [0, 1] is possible. The degree of membership is given in this case. The graphical tools to help the users are available in the Fuzzy logic systems typically for converting attribute values to fuzzy truth values. The imprecise, vague or inexact facts measurement of the data is possible with the fuzzy logics. In the traditional "crisp" sets an element either belongs to a set S or its complement. In fuzzy set theory, elements can belong to more than one fuzzy set. Fuzzy set membership values for given element x do not have to sum to 1. In probability theory, constrain is given by summation axiom.

Applicability of the fuzzy prototype systems is found in the several areas of the medial science and image processing is required. The medical devices like X-ray machines, MRI scanning machines produces the images, may not clearly shows the defects caused in the human bodies. Even the mammography based, back pain images, unclear human bone images, image edge detection, satellite based image processing, blur, noisy image requires the fuzzy based decision support system. We are looking for the fuzzy based DSS for better scheduling policies.

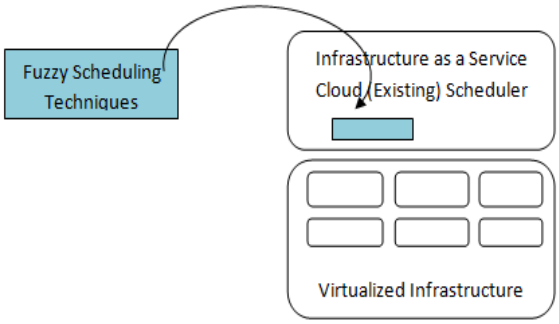

Fig. 1: Embodiment of Fuzzy Scheduling in Cloud Scheduler.

Figure 1 shows the fuzzy scheduling embodiment in the Cloud Scheduler. This requires the combination of the different membership functions for the input conditions, output and constraints to solve the fuzzification, defuzzification etc.

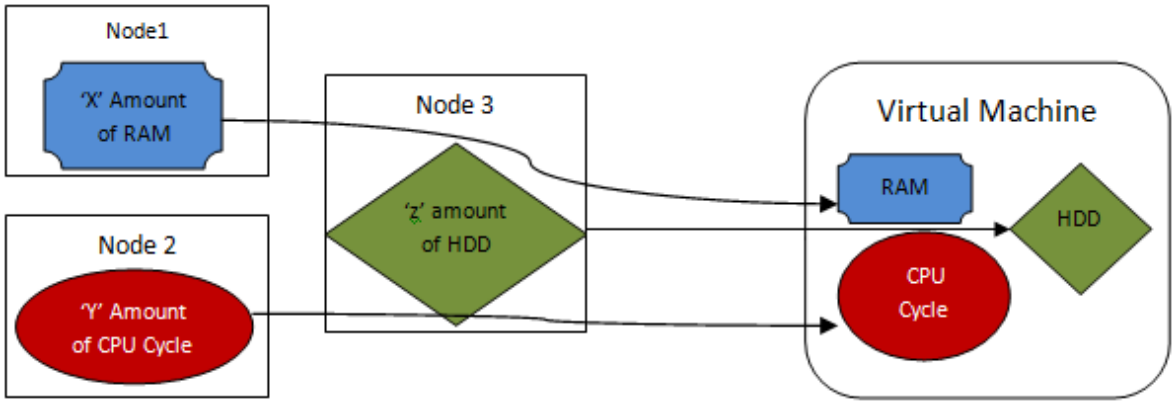

Fig. 2: Creation of Virtual Machine from fraction of Resources.

Figure 2 shows the fraction of resources available in discrete fashion and creation of the virtual machines. The next section illustrates the mathematical explanation of the membership function. We have used the Jfuzzylogic library[20][21] to demonstrate the use of the membership functions.

II. BACKGROUND

Jacob et. al, [1] analyzes the performance of K-Means Clustering Algorithm running on Hadoop MapReduce on Eucalyptus platform. The customization for running hadhoop on Eucalyptus need tools like Ganglia and TestDSFIO.java has been discussed. The K-Means Clustering Algorithm scales up with number of nodes on Eucalyptus Cloud. The Results of measurement of the disk, network, memory, bandwidth, data throughput and average I/O are evaluated.

Aswin et. al. [2] developed the efficiency and quality of service improvement 3-tier framework is applied over application layer and Network layer. The energy and load aware algorithm has been developed.

Kashyap et. al. [3] discussed Portability, interoperability and standard development in the Clouds.

K. Dinesh et. al, [4] focuses on job scheduling using Berger model and Neural Network for task resource matching based on different parameter s like bandwidth, memory, Completion time and Resources Utilization. The classified user tasks are passed to the neural network consists of input layer, hidden layer and output layer. With the help of hidden layer, the jobs are matched with the resources by adjusting weight. The performance of the system has been improved by means of efficient use of bandwidth, reducing a completion time which in turn improves resources utilization. CloudSim, a simulation tool has been used to simulate and the results shows reduced completion time and increased performance of the system.

Marin Marinov et. al, [5] attempts to apply the intuitionist fuzzy sets (IFS) paradigm to construct an efficient load balancing scheme in Cloud Computing environment. Two approaches of IFS usage are shown. One is based on a direct substitution of a classical fuzzy logic by an intuitionist fuzzy logic, illustrated on an already proposed model of load balancing. The second approach deals with the application of the modal notions from IFS – necessity and possibility, which are proposed to be associated to the needed load and available resources respectively.

Suresh Kumar et. al, [6] considers many task computing (MTC) in the multiple Cloud environment managing on the virtualized environment. The NS2 simulator based genetic algorithm is used to find the approximate solutions during the service selection task.

Suresh Kumar et al., [7] discusses the behavior of a Cloud data center by means of various aspects like availability, utilization, responsiveness and waiting time in energy efficient environment. The various factors like elasticity, scalability, live migration of VMs and performance isolation should be considered. The OpenStack Cloud system has been used. This simulated the nature of honey bee colony with the use of fuzziness to capture all the possible run time entities.

Praveena et. al., [8] proposed the privacy-preserving system using Attribute based Multifactor Authentication. Proposed system provides privacy to user data with efficient authentication and store them on Cloud servers such that servers do not have access to sensitive user information. Meanwhile users can maintain full control over access to their uploaded files and data, by assigning fine-grained, attribute-based access privileges to selected files and data, while different users can have access to different parts of the System. This application allows clients to set privileges to different users to access their data.

Rajani Kumari et. al, [9] designed and implemented the of modified fuzzy based CPU scheduling algorithm and improvement found over the average waiting time and average turnaround time.

Daniel Ramot et. al, [10] discusses a complex fuzzy set for logical reasoning, which is a generalization of traditional fuzzy logic. Here, inference rules are constructed and "fired" for reasoning process characterized by complex-valued membership functions. The range of these membership functions is extended from the traditional fuzzy range of [0,1] to the unit circle in the complex plane, thus providing a method for describing membership in a set in terms of a complex number.

V. Prasath et. al., [11] performed the generalization of characteristic function of a crisp set and universal set X are in focus of the problems. Such a function is called a membership function and the set defined by it a fuzzy set. We accept the fact (premise, hypothesis, antecedent) then we can infer another fact called conclusion (consequent). The human knowledge is represented using IF-THEN expression. This form generally is referred to as deductive form.

Santhosh et al. [12] considered the cost of task execution during the resource management and virtual machine migration. The checkpoint methodology is used during the migration. It significantly outperforms the Non Preemptive scheduling with task migration algorithm.

Satsangi et. al, [13] tests gives three fuzzy inputs like Gracefulness, Processor Speed and Performance and find out Trust Rating. Cloud-based model can be more robust, scalable and cost effective and would Manage risk very well with the use of fuzzy Logic .

Rizwana et.al [14] discussed about CloudSim, UEC (Ubuntu Enterprize Cloud), OpenStack tool. The simulators are necessary before deployment of actual Cloud based experimentation with respect to available tools to perform testing and setting up the benchmarks. An analysis by considering various parameters of such tools is presented to provide guidelines about their working with Cloud.

Sharath et. al. [15] benchmarking based on performance comparison for two IaaS Clouds Eucalyptus 3 and OpenStack implemented on FutureGrid. Phoronix Test Suite is utilized as a benchmark program to conduct diverse performance measurements on both the Cloud. The various parameters like time to launch instances, time to register images using scripts are being used.

Yadav et. al., [16] used a Fuzzy Expert System (FES) for student academic performance evaluation with suitable fuzzy inference mechanism and associated rule has been discussed. It introduces the principles behind fuzzy logic and illustrates how these principles could be applied by educators to evaluating student academic performance. Several approaches using fuzzy logic techniques have been proposed to provide a practical method for evaluating student academic performance and compare the results (performance) with existing statistical method.

Yen et. al., [19] discusses theory, applications mathematical models useful for the basic fuzzy logic system.

III. MATHEMATICAL MODELLING OF MEMBERSHIP FUNCTIONS

With reference to the Trapezoidal Member function [22] denoted by the equation (1). Trapezoidal member function is curve of vector x, and depends on four parameters a,b,c, and d given by. Parameter a and d locate the feet of the trapezoidal. Parameters b and c locate the shoulders.

$$f(x;a,b,c,d) = \begin{cases} 0, & x \le a \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \\ 0, & d \le x \end{cases} \quad \text{.....(1)}$$

The same equation can be represented in more compact form as following.

$$f(x;a,b,c,d) = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), o\right) \quad \text{.....(2)}$$

A. Gaussian curve membership function

Gaussian curve membership[22] function is given by equation (3).

$$f(x;\sigma,c) = e^{\frac{-(x-c)^2}{2\sigma^2}} \quad \text{.....(3)}$$

The parameters of Gaussian membership function are given by vector c.

The Fuzzy control Logic parameters in the .fcl file are presented for Gaussian membership as :

```
FUZZIFY OWNER_CONDITIONS
        TERM low := gauss 2 2 ;
        TERM medium := gauss 5 2;
        TERM high := gauss 8 2;
END_FUZZIFY

FUZZIFY OCCUPIED_CAPACITY
        TERM low := gauss 2 2 ;
        TERM medium_low := gauss 5 2;
    TERM medium_high := gauss 8 2;
    TERM high := gauss 7 2;
END_FUZZIFY
```



```
DEFUZZIFY DEFUZZIFY ALLOCATION_CHANCE
        TERM very_low := gauss 5 2;
        TERM low := gauss 8 2;
        TERM medium_low := gauss 3 2;
        TERM medium_high := gauss 4 2;
        TERM high := gauss 6 2;
        TERM very_high := gauss 5 2;
        METHOD : COG;
        DEFAULT := 0;
END_DEFUZZIFY
```

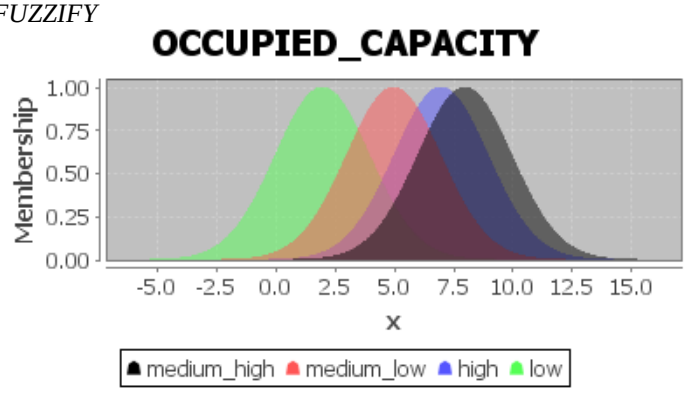

Fig. 3 Occupied Capacity presented using Gaussian membership Function

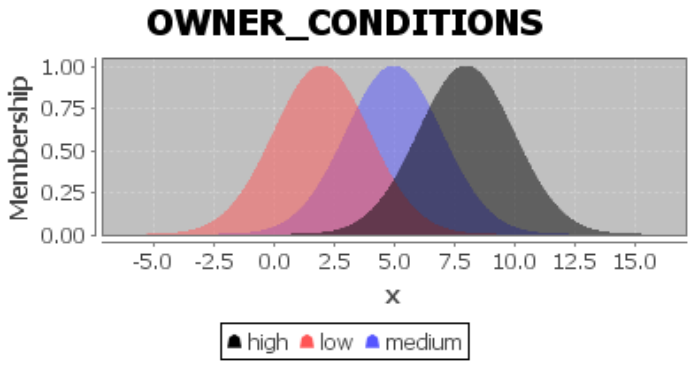

Fig. 4: Owner's conditions represented using Gaussian membership Function

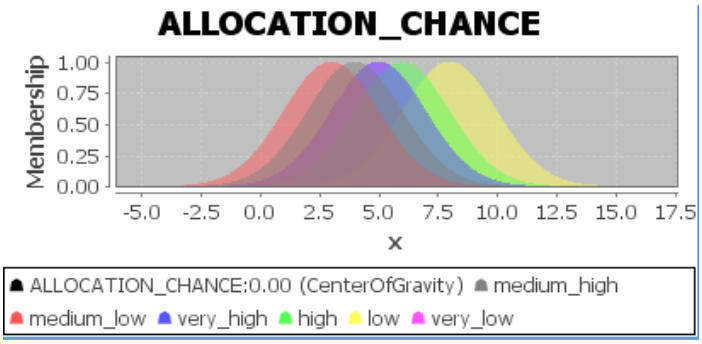

Fig. 5: Allocation Chances represented using Gaussian membership Function

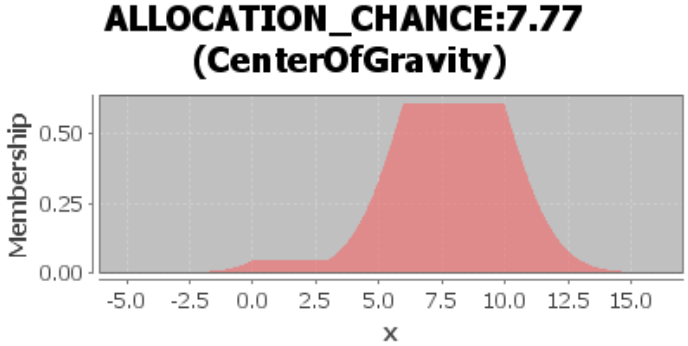

Fig. 6: Allocation Chance (Centre of Gravity) represented using Gaussian membership Function

B. Generalized bell function

The generalized bell function given by three parameters a, b, c,

$$f(x;a,b,c) = \frac{1}{1+\left|\frac{x-c}{a}\right|^{2b}} \quad \text{.....(4)}$$

Where the parameter b is usually positive. Parameter c locates the centre of the curve.

The fuzzy control logic code in separate file represented as:

```
FUZZIFY OWNER_CONDITIONS
        TERM low := gbell 2 4 2 ;
        TERM medium := gbell 2 4 5;
        TERM high := gbell 2 4 8;
END_FUZZIFY
FUZZIFY OCCUPIED_CAPACITY
        TERM low := gbell 2 5 7 ;
        TERM medium_low := gbell 2 3 6;
    TERM medium_high := gbell 2 4 8;
    TERM high := gbell 2 4 7;
END_FUZZIFY
DEFUZZIFY DEFUZZIFY ALLOCATION_CHANCE
TERM very_low := gbell 1 4 6;
        TERM low := gbell 1 4 6;
        TERM medium_low := gbell 1 4 6;
         TERM medium_high := gbell 1 4 6;
         TERM high := gbell 1 4 6;
        TERM very_high := gbell 1 4 6;
        METHOD : COG;
        DEFAULT := 0;
END_DEFUZZIFY
```

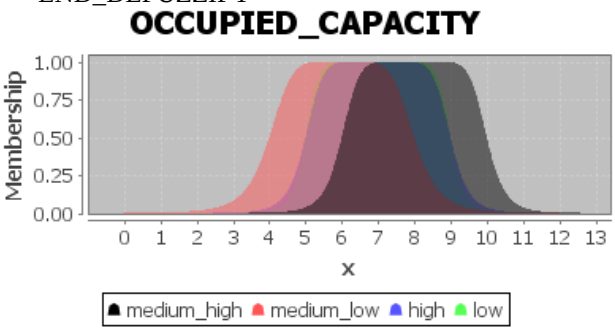

Fig. 7 Occupied Capacity presented using generalized bell function

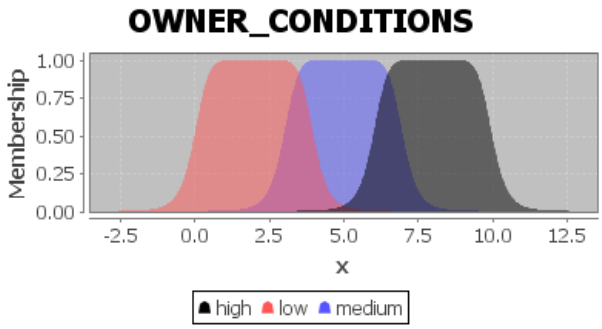

Fig. 8: Owner's conditions represented using Generalized bell function

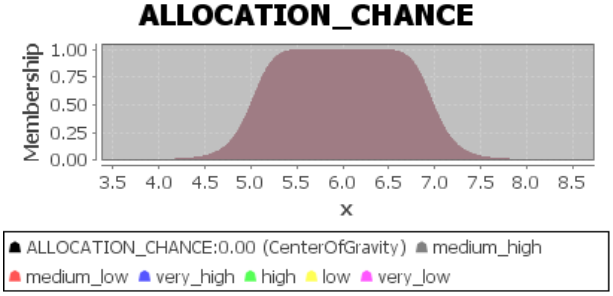

Fig. 9: Allocation Chances represented using generalized bell function

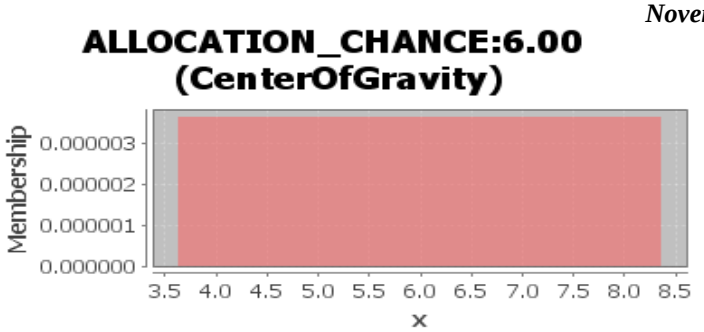

Fig. 10: Allocation Chance (Centre of Gravity) represented using generalized bell function

C. Singleton Membership Function

We can also use the Singleton Function for having very certain values of the input conditions. The Singleton function defined as

The Set S is called as singleton when, if and only if, there is only one y € X such that, for all x € X. and b(x)= (x=y)

The fuzzy control logic code in separate file represented as:

```
FUZZIFY OWNER_CONDITIONS
        TERM low := 2 ;
        TERM medium := 5;
        TERM high := 8;
END_FUZZIFY
FUZZIFY OCCUPIED_CAPACITY
        TERM low := 1 ;
        TERM medium_low := 3;
       TERM medium_high := 5;
      TERM high := 9;
END_FUZZIFY
DEFUZZIFY DEFUZZIFY ALLOCATION_CHANCE
        TERM very_low := 1;
        TERM low := 2;
        TERM medium_low := 4;
         TERM medium_high := 7;
        TERM very_high := 9;
        METHOD : COG;
        DEFAULT := 0;
END_DEFUZZIFY
```

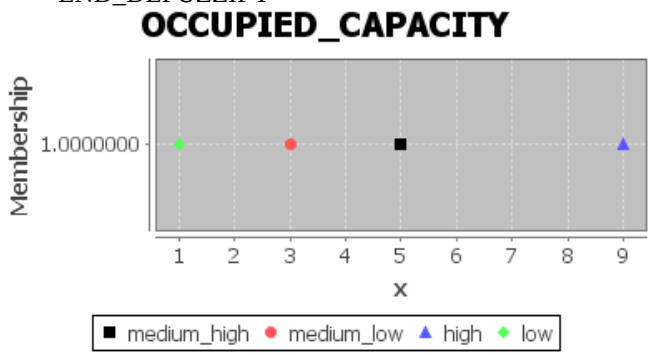

Fig. 11 Occupied Capacity presented using Singleton function

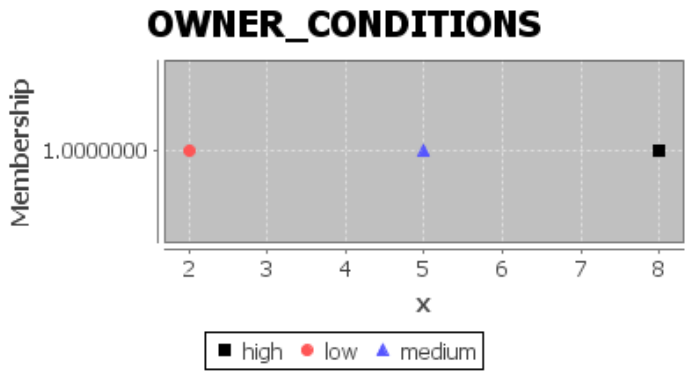

Fig. 12: Owner's conditions represented using Singleton function

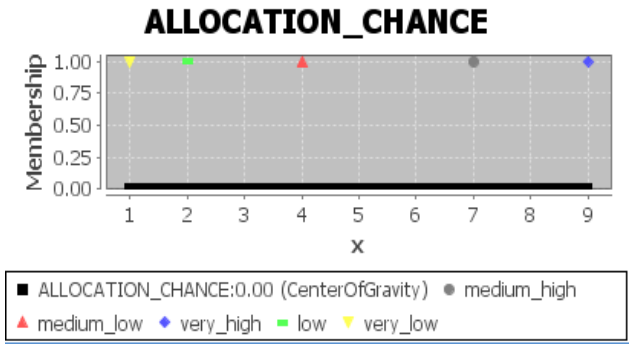

Fig. 13: Allocation Chance represented using Singleton function

D. We can also use the Sigmoid Function [22] for having very certain values of the input conditions. The Sigmoid function defined as

$$S(t) = \frac{1}{1 + e^{-t}}. \quad \text{.....(5)}$$

The fuzzy control logic code in separate file represented as:

```
FUZZIFY OWNER_CONDITIONS
        TERM low := sigm -4 3 ;
        TERM medium := sigm 4 3;
        TERM high := sigm 5 8;
END_FUZZIFY
FUZZIFY OCCUPIED_CAPACITY
        TERM low := sigm -5 -1 ;
        TERM medium_low := sigm -3 1;
        TERM medium_high := sigm -2 3;
        TERM high := sigm 2 6;
END_FUZZIFY
DEFUZZIFY DEFUZZIFY ALLOCATION_CHANCE
        TERM very_low := sigm -8 -5;
        TERM low := sigm -5 -3;
        TERM medium_low := sigm -3 1;
         TERM medium_high := sigm -1 -4
        TERM very_high := sigm  1 6;
        METHOD : COG;
        DEFAULT := 0;
END_DEFUZZIFY
```

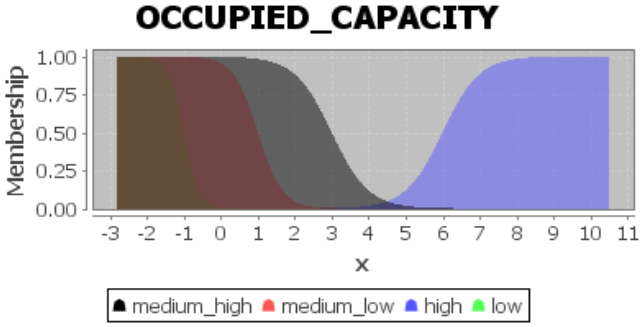

Fig. 14 Occupied Capacity presented using Sigmoid function

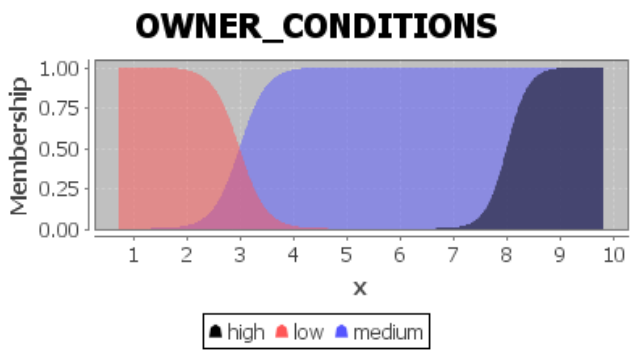

Fig. 15: Owner's conditions represented using Sigmoid function

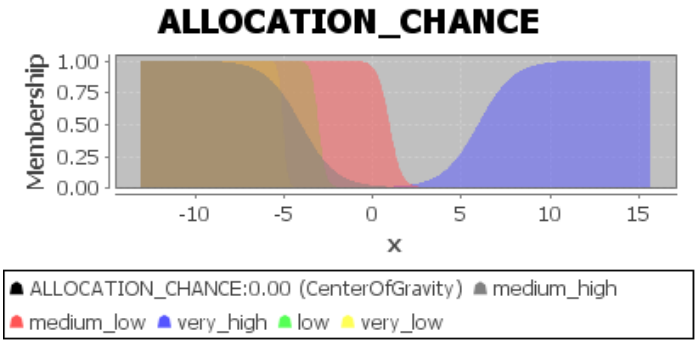

Fig. 16: Allocation Chance represented using Sigmoid function

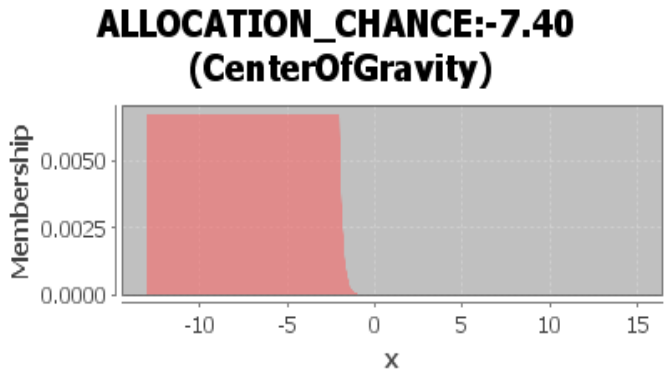

Fig. 17: Allocation Chance (Centre of Gravity) represented using sigmoid function

It is possible to have piecewise linear Function equations to mention the input conditions, where a piecewise linear function is a function composed of straight-line sections.
The common rule base section, which is useful as a knowledge base for decision making.

```
RULEBLOCK No1
        AND : MIN;
        ACT : MIN;
        ACCU : MAX;
   RULE 1:
   RULE 2:
   RULE 3:
END_RULEBLOCK
```

IV. CONCLUSIONS

The suitability of the sigmoid, singleton, generalized bell, Gaussian, trapezoidal, triangular functions is done here with the help of the fuzzy control logic in the context of the lease processing system in the IaaS Cloud environment. It will be useful to check the applicability of the piecewise linear function. It is also interesting to find out the use of min, max, mid function in triangular membership function. Similarly, min, midlow, midhigh, max functions in case of the trapezoidal function. The results of the Gaussian membership functions could be checked with mean and standard deviation. The generalized bell, Gaussian membership function available with its own flavors to be useful for creating more precise mathematical model for uncertain conditions of the Cloud lease processing.

ACKNOWLEDGMENT

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