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Better Resource Provisioning in Cloud Computing Using Fuzzy System

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Abstract: Cloud computing is one of the most promising technologies in which a good number of the researchers are doing research. Out of the various challenges in this field, one challenge is regarding the precise and reasonable resource provisioning to submitted jobs. Organizations prefer hybrid clouds for keeping their secure data on private cloud and rest of the data on public cloud .Our work involves building and implementing decision making model that will determine route the cloud computing processes will follow to go to appropriate cloud for resource provisioning. The decision is based on parameters such as priority, age and execution time required for the process. The simulation results improve performance in terms of security, accuracy, response time and resource utilization.

Keywords: Cloud Computing, Resource Provisioning, Hybrid Cloud, Fuzzy Logic, Soft Computing.

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I. INTRODUCTION

1.1. Cloud Computing

Cloud Computing, as the name implies, is the system of computing that contains various hardware and software resources that can be delivered to the customers on the basis of resources requested[1].These resources are provided to the consumers as services. The cloud consumers use these resources and pay on the basis of resources requested. They don't know where these services are located .They just use these resources when needed and release them when they are no longer required[2]. As per NIST "Cloud computing[3] is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services)that can rapidly be provisioned and released with minimal management effort or service provider interaction". Cloud computing provides three types of services which are Infrastructure as a service (IAAS) for provisioning of hardware resources, Platform as a service (PAAS) for providing application development environment where user can code, test and deploy their applications and Software as a service (SAAS) for providing readymade software applications to the cloud consumers. Cloud providers are broadly classified into four categories: public cloud, private cloud, hybrid cloud and community cloud. Public cloud services are open to anyone who is on internet[4]. Advantages of public cloud include scalability, inexpensiveness with continuous availability of services. Its disadvantages include lack of data security and privacy. Private cloud provides services to the organizations in which it is built and managed[5].Its main advantages as against public cloud are security and privacy but its disadvantage is that it is expensive .Both private and public cloud provides complimentary benefits .To enjoy the benefits of both private cloud and public cloud, an organization prefer to use hybrid cloud. In simple sense, hybrid cloud is the intermixing of both public cloud and private cloud. The cloud shared by many organizations is the community cloud[6].Cloud resource provisioning is a painstaking job[7].Resources can be allocated easily when they are sufficiently available but there will be problem when required resources are not sufficiently available. Resource provisioning involves activities like identification of available resources and selection of best resource-workload match while considering Quality of Service (QOS) requirements submitted by the user in terms of Service Level Agreement (SLA) provided[7].It helps in reducing cost and time required while maximizing resource utilization. Various cloud computing based resource provisioning mechanisms are covered in our recent work[8].These mechanisms are as follows:

- Hybrid Based
- Reliability Based
- Queuing Model Based
- Ontology Based
- Deadline Based
- Service Level Agreement (SLA) Based

- Cost Based.
- Application Based

1.2. Fuzzy Logic

Fuzzy Logic is a tool which provides a way of decision making where input information is vague, ambiguous and imprecise or missing[9]**.**Fuzzy Logic is a four step process. In every problem, Fuzzy Logic follows a sequence of four steps which is defined as follows:

Fuzzification defines membership functions for the linguistic terms for fuzzy variables[10].Various types of membership functions are there and the selection of the particular membership function depends upon application for which they are designed. Second is designing **Rule base**. Broadly, there are three approaches for designing a rule base. Mamdani Systems, Sugeno systems, Tskamoto Models. Third is **Firing of Rules** with their varying strengths. The last step is **defuzzification** which is the process of obtaining crisp output from fuzzy output. There are many approaches of defuzzification like centroid method, weighted average method, min-max method etc.

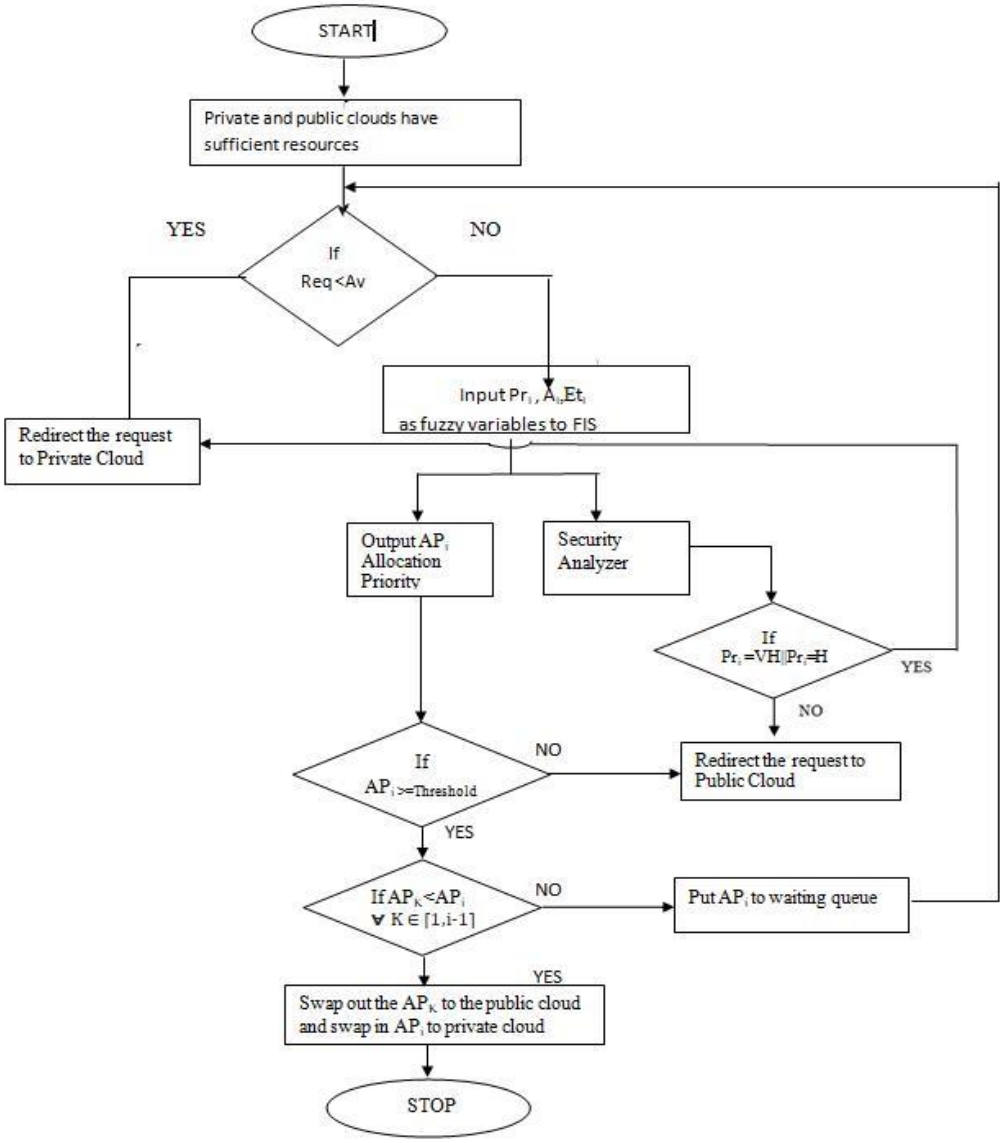
II. LITERATURE REVIEW

An on demand resource provisioning[11] in multiple clouds has been implemented on Cloud Sim v2.1.1 and the results have shown that proposed approach helps in increasing resource utilization and proves to be cost-effective. A failure aware resource provisioning[12] for hybrid cloud infrastructure has been proposed where a hybrid cloud resource provisioning along with the failure recovery policies have been proposed. The proposed policy has been implemented on cloud Sim. Results have revealed that the proposed policy is able to improve QOS by improving 32% in case of deadline violation rate and 57% in case of slowdown. A dynamic resource provisioning[13] in cloud based on queuing model has been proposed where the resources are allocated dynamically to the requests with Banker's algorithm avoiding the situation of deadlock. The proposed system is simulated on Hadoop, a cloud computing simulator. The results show that the proposed system provides less response time in serving requests. Another rule based approach[14] for effective resource provisioning in hybrid cloud environment has been proposed which is simulated on Cloud Sim 3.0.The results have shown that private cloud utilization is found to be 70.59% with rule based approach as compared to 64% with non rule based approach, Another resource management[15] in a hybrid cloud infrastructure has been proposed where the priority has been given to the user's requests on the basis of VMs requested and the processes are routed to appropriate cloud accordingly. The proposed policy has been implemented on Cloud Sim 3.0 and help in decreasing overall outflow of the organization. A cost-effective service provisioning[16] for hybrid cloud applications has been proposed where the private cloud is utilized for fulfilling resource requests then the public clouds are utilized. As the price of public cloud changes with time, this policy adjusts accordingly. Other features of this policy include maintaining cost-effectiveness and focusing on load balancing problem.

In the above literature, various cloud based resource provisioning mechanisms have been summarized. In the following sections, we are briefing some of the applications of fuzzy logic in cloud computing. An efficient load balancing scheme[17] in cloud computing has been proposed using fuzzy logic where a new load balancing algorithm is projected and is compared with the existing round robin load balancer. The results obtained show that fuzzy logic based load balancing algorithm helps in load balancing by decreasing processing time as well as improving overall response time. A job scheduling[18] using fuzzy neural network algorithm in cloud environment has been proposed where fuzzy logic fuzzifies bandwidth, memory, time and the genetic algorithm is used for mapping the system resources with the jobs and the again fuzzy logic performs defuzzification process. The algorithm is compared with conventional model and the results show that the proposed technique results in reduction in bandwidth utilization and completion time. A fuzzy-based firefly algorithm[19] for load balancing in cloud computing has been presented where the cloud is partitioned into heavy and least loaded nodes. With this approach, the best suitable node for the existing load is preferred and firefly algorithm helps this load to get fascinated towards that division. Here, a balance factor is calculated. If the balance factor is greater than 1 then fuzzy logic handles this situation. The proposed algorithm is compared with the genetic algorithm approach and the result shows that this approach consumes less execution time, incurs less cost, can handle much heavier load, and balances a good amount of arrived load as compared to genetic algorithm**.** A fuzzy logic based risk assessment approach[20] for evaluating and prioritizing risks in cloud computing environment has been proposed**.** The model is based on fuzzy logic to deal with inadequate and deficient information. Here, impact of risk and probability of risk have been fuzzified and the defuzzified value is obtained which is the crisp risk rate and the calculated crisp risk rate is compared with the expected risk rate to show the accuracy of the proposed technique.

While provisioning resources in hybrid cloud, priority conflict situation is there. The existing approach is uni-dimensional, that is, only security is considered for defining the priority to the process. Our aim is to address the problems discussed above and also improve the existing approach in terms of response time, security

and accuracy and resource utilization. We have applied fuzzy logic in cloud computing for allocating priorities to the cloud computing based requests for resources.



III. DESIGN OF THE MODEL

We have added a fuzzy inference system (FIS) to the existing system hybrid model where we assume that private and public clouds have sufficient resources. If requested resources are available at private cloud, the resources are allocated from there otherwise FIS will handle the situation. The fuzzy logic part is designed and implemented in MATLAB[21] in our previous paper[22]and is explained as follows The fuzzy logic approach in our work is as follows:

- **Fuzzification**

For fuzzification, we have taken 3 Fuzzy variables.

1. Priorities on the basis of security and importance
2. Age
3. Execution time

Data in the form of clubbed priority on the basis above inputs is collected from the IT professionals. The membership functions of three input fuzzy variables and fuzzy output variables are defined as follows:

1. Security and Importance:

We have taken triangular membership function for defining security and importance

$$\mu_H(x) = \begin{cases} 0 & if\, x \le .4999 \\ \frac{x-.4999}{.75-.4999}\, if\, x \in (.4999,.75) \\ \frac{1-x}{1-.75} & \text{if } x \in (.75,1) \\ 0 & \text{if } x \ge 1 \end{cases}$$

2. Age:

We have taken Gaussian membership function for defining age.

$$= \quad - \quad -.75^2/2*.1062^2]$$

3 .Execution Time

Here, we have used triangular function.

$$\mu_M(x) = \begin{cases} 0 & if\, x \le .2499 \\ \frac{x-.2499}{.5-.2499} & if\, x \in (.02499,.5) \\ \frac{.7501-x}{.7501-.5} & \text{if } x \in (.5,.7501) \\ 0 & \text{if } x \ge .7501 \end{cases}$$

4. Allocated Priority

The allocated priority is the clubbed priority allocated to each process. For this, we have used triangular function.

$$\mu_M(x) = \begin{cases} 0 & if\, x \le .2499 \\ \frac{x-.2499}{.5-.2499} & if\, x \in (.2499,.5) \\ \frac{.5-x}{.7501-.5} & \text{if } x \in (.5,.7501) \\ 0 & \text{if } x \ge .7501 \end{cases}$$

- **Defining Rule Base:** On the basis of IT professional's responses, rule base in our research is designed. In our work, we have used Mamdani approach for defining rule base using if then statements:

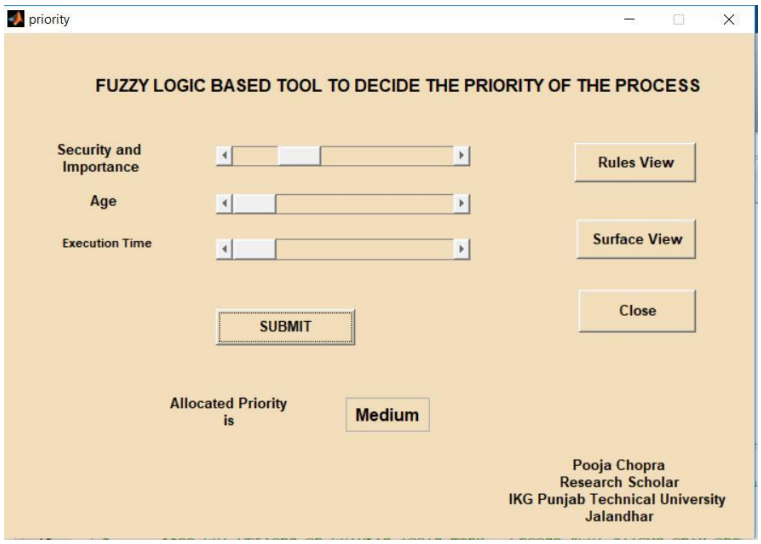
R_1: if *security* is *very high* and *age* is *very high* and *execution_ time* is *very high* then *Allocated_Priority* is *high.*
Like wise, 57 rules have been defined in the Rule Base.

- **Defuzzification**: Defuzzification is the process of discovery of crisp value from fuzzy output set as crisp value is crucial for any action to be taken. In our work, we have used centroid method for defuzzification. Following formula is used as centroid method

$$z_0 = \frac{\int \mu_i(x)\, x\, dx}{\int \mu_i(x)\, dx}$$

Where z_0 is the defuzzified output, μ_i is a membership function and x is an output variable.

A graphical user interface is designed for taking inputs in the form of security, age and execution time and giving outputs in the form of allocated priority. A sample screen shot is shown as below:



4. Implementation and Testing

On the basis of testing data, the expert responses and our system responses are collected and checked for uniformity by applying Mann Whitney test[23] to check the accuracy of our system. The results of experts and our system are shown in the following table:

Table I: Results of FIS and Experts

Sr.No	Input Parameters			System Output	Expert1 Output	Expert2 Output	Expert 3 Output
	Security	Age	Execution Time				
1	Very High	Very High	Medium	High	High	Very High	High
2	Very High	Very High	Low	High	Very High	Very High	High
3	Very High	High	Low	High	Very High	Very High	High
4	Very High	Medium	Very Low	Very High	High	Very High	Very High
5	Very High	Low	High	Medium	High	High	High
6	Very High	Low	Low	High	Medium	High	High
7	High	High	Very High	High	Medium	Medium	High
8	High	Low	Very High	Medium	Medium	Medium	Medium
9	High	Low	Medium	High	Medium	Medium	Medium
10	Medium	High	Very High	Low	Low	Low	Low
11	Medium	High	Medium	Medium	Medium	Medium	Medium
12	Medium	High	Very Low	High	High	High	High

13	Medium	Medium	Low	Medium	Medium	Medium	Medium
14	Medium	Low	Medium	Low	Low	Low	Low
15	Low	High	Medium	Low	Low	Low	Low
16	Low	Medium	Low	Medium	Low	Low	Medium
17	Low	Medium	Very Low	Medium	Medium	Medium	Medium
18	Low	Low	Very Low	Medium	Very Low	Very Low	Medium
19	Low	Very Low	High	Very Low	Very Low	Very Low	Very Low
20	Very Low	High	Medium	Low	Low	Very Low	Low
21	Very Low	Medium	High	Very Low	Very Low	Very Low	Very Low
22	Very Low	Medium	Very Low	Medium	Low	Low	Medium
23	Very Low	Low	Very High	Low	Very Low	Very Low	Low
24	Very Low	Very Low	Very High	Low	Very Low	Very Low	Low
25	Very High	High	Medium	High	Very High	Very High	High
26	Very High	Low	Very Low	High	Very High	Very High	High
27	High	Very High	High	High	Very High	Very High	High
28	Medium	Low	Very Low	Medium	Medium	Medium	Medium
29	Medium	Very Low	Very Low	Medium	Medium	Medium	Medium
30	Low	Very High	Low	Medium	Medium	Medium	Medium
31	Low	High	Low	Medium	Low	Low	Low
32	Low	High	Very Low	Medium	Medium	Medium	Medium
33	Low	Low	Medium	Low	Low	Low	Low
34	Very Low	High	High	Medium	Very Low	Very Low	Medium
35	Very Low	Medium	Low	Medium	Very Low	Very Low	Medium

The defuzzified output generated is compared with the predefined threshold value. If the defuzzifed value is less than threshold limit, the resources will be provisioned from public cloud otherwise resources will be provisioned from private cloud. If on private cloud, there is already a process of low defuzzified priority as compared to arrived request with high defuzzified priority, in that case high defuzzified priority request will be swapped into the private cloud and request with low defuzzified priority will be swapped out to public cloud.

Another feature of security analyzer is there. The security analyzer will check the security parameter of the process. If it is high or very high, the process will be routed to the private cloud as private cloud is considered more secure than public cloud.

5. Simulation and Results: Cloud Sim3.0 is used for simulation of results generated from our proposed system. The following parameters metrics are taken:

1. CPU Utilization

The CPU utilization rate is calculated as the percentage of CPU being used in a given time interval.

Percentage of Server Utilization, = $\frac{}{} \times 100$

Where total response time, = , T_i= Time taken by i_{th} individual request and= time taken by the fuzzy logic based decision making process. The calculation of server utilization is based upon a total of 35 requests taken as samples and executed using CloudSim 3.0 environment[24].

= 0.00075947 * 35 = .02658145 sec

= 0.289142801 sec

2. Security

In our work, the processes that are highly sensitive are directed to private cloud as public cloud is prone to outside attacks.

3. Accuracy

The consistency of experts' results and system results is obtained using Mann-Whitney test and hence proved the accuracy of the system.

4. Response Time

When the processes go to public cloud, the response time is 889523.4363839998 nano seconds. When the processes go to private Cloud, the response time is 296507.81401800003 nano seconds whereas it is 289142.8009020001 nano seconds, when the processes go through fuzzy logic based system

IV. Conclusion

Our paper is based on comparing two approaches i.e. when the entire processes are directed towards a particular cloud and when the entire processes are directed towards hybrid cloud where fuzzy inference system will decide the appropriate cloud where to direct the processes. The proposed approach using Fuzzy Logic helps in improving CPU utilization, decreasing response time, improving accuracy while promoting security.

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