Framework for Ranking Service Providers of Federated Cloud using Fuzzy Logic Sets

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***Abstract*-- Federated cloud architecture is heterogeneous and distributed model that provides infrastructures related to cloud by aggregating different IaaS providers. In this case, it is an exciting task to select the optimal service cloud provider for the customer and deployed it. In this paper, new provider discovery algorithm and fuzzy logic sets ranking model is proposed in the modified federated architecture and the performance is evaluated. Proposed discovery method shortlists the provider based on the Quality of Service (QoS) indicators suggested by SMI with SLA that provides improved performance, in addition to that, the cost is also included that represent the fulfillment at the level of end user. Ranking mechanism based on Fuzzy logic set approach having three general phases such as problem decomposition, judgment of priorities and aggregation of these priorities. Fuzzy set may be combined QoS indicators with some simple rules. Weighted Tuned Scheduling Algorithm proposed to resolve the issue of starvation in the existing architecture and manage the requests effectively. Experimental results show that proposed architecture have better successful selection rate, average response time and less overhead compared to the existing architecture that supported cloud environment.**

1. INTRODUCTION

Cloud computing is a promised paradigm that offers simple, flexible, scalable and cost effective outsourcing type of services such as application development and hosting to the customers on demand and pay per utilization. Service Level Agreement (SLA) is an agreement that illustrates the level of performance assured by the provider at the user side [1]. In current scenario, SLA technique plays a major role that brings the confident to the user, prompts business policies and ensuring Quality of Service (QoS) at user side. SLA management provides with three phases such as SLA establishment, SLA negotiation, SLA monitoring and violation. Cloud provider commits to the user in terms of QoS is called as SLA establishment whereas the user discuss with the provider for the required level of services called as SLA negotiation. Services consumed by the user are monitored by the provider and detecting if there is any abnormality is remarked as violation. SLA is implemented between cloud member and cloud service provider for efficient processing of federated cloud [3]. SLA management is maintained in the proposed architecture by discovering and ranking the service providers for the user based on fuzzy logic sets.

Federated cloud architecture is heterogeneous and distributed model that provides infrastructures related to cloud by aggregating different IaaS providers. In this case, it is an exciting task to select the optimal service cloud provider for the customer and deployed it. Cloud Service Measurement Index Consortium (CSMIC) [16] has identified some metrics in the form of Service Measurement Index (SMI) that helps to evaluate and compare the services of different cloud providers. Ranking the cloud service providers based on these SMI metrics is a challenging task because the value of the metrics determined and selected, the algorithm used for ranking and the performance of the selected provider. In the proposed architecture, cloud broker Manager is responsible for selecting the best cloud providers, in addition, performing QoS monitoring, SLA verification and ranking the matched service providers.SLA is encompassed for the user by discovering appropriate service provider, describe and define their services properly, negotiate and delivers the service as per in the agreement [15]. SLA level policies are monitoring by the Broker Manager for the specific user, if there is any violation found, the penalty will be imposed.

Initially, differential treatment is applied to identify the category of the user, maintain the SLA based on the user profile, apply concept of fuzzy logic set to rank the cloud providers and allocate the top provider to the user. Strict differential treatment leads to the starvation but it is resolved using the proposed scheduling algorithm called weighted Turned Queuing scheduling (WTQS). Cloud Broker Manager (CBM) is responsible for resource

provisioning in proposed federated cloud. Each provider has interconnected with broker.SLA is verified with the information available in broker registry for the user. In this paper, a new selection method is suggested that combines Quality of Service (QoS) indicators with SLA that provides better performance, in addition to that, the cost is included that represent the fulfillment at the level of end user. It also describes how the SLA management is effectively designed for the users by enabling to integrate the service levels and efficient interoperability is achieved using brokers. This paper is organized as section 2 describes the related work of ranking the providers. Section 3 illustrates the architecture, discovery of providers and fuzzy logic set ranking technique. Section 4 reveals the performance of the proposed architecture and section 5 discuss with conclusion.

2. Related Work

Rajkumar Buyya et.al [5] describes market based provisioning policies for flexible allocation of resources to applications in cloud. Resource allocation was carried out based on the support for customer driven service management based on customer profiles, Quality of Service requirements, risk management with respect to applications and sustain SLA. This work was effectively implemented using the Aneka platform. Rule based resource manager [6,13] was proposed to utilize the private cloud resources, considering the security requirements of applications and data. Resource manager is the component that allocates the resources on demand even the cloud is overloaded. In the proposed approach, the user request is categorized into critical data processing and security. Based on the type of requests, priority is assigned and redirected the request to the suitable cloud.

M.Aramudhan et.al [7]. proposed a new framework for cloud that maintains the SLA by means of distinguished the incoming requests either SLA based member or SLA based non-member. This policy brings starvation that avoids by introducing a new algorithm called Distributed Loose Priority based scheduling. In addition to that the cloud providers are ranked based on plot care method and the average response time of the requests were calculated, analyzed and compared with existing method. Praveen Ganghishetti et.al [8]. used the concept of rough set theory to allocate the best service provider to the cloud users with minimum searching time. Cloud broker was used in this architecture that helps to allocate resources based on Service Level Agreement between users and providers for Infrastructure as a Service. Cloud providers publish their service along with all types of QoS parameters in cloud registry and later the MCQoS algorithm used to invoke it.

Rajkumar Buyya et.al [2,9] discussed the framework which measures the quality, prioritizes and selects the cloud services based on SMI metrics and ranking the services using Analytic Hierarchy Process (AHP). It is one of the flexible ways for solving and adapted to any number of attributes with any number of sub- attributes. AHP model has three phases such as forming hierarchy structure, pair wise comparisons and find aggregated value to generate ranking of the services. Authors proposed service mapper that contains a technique called singular value decomposition which is used for ranking the services in statistical manner.

Choudhury et al [10,14] proposed a system called Service Ranking System (SRS). This system has two type ranking: static and dynamic. In the static ranking, all available cloud service providers are ranked without considering user requirements. But in dynamic ranking, suitable services ranked based on user requirements.

3. Proposed Ranking based Federated Architecture

A modified Federated resource provisioning model consists of three phases namely (i) Discovery of service providers (ii) Rank the selected service provider using Fuzzy logic sets (iii) assigning the service to the best service provider. The customized federated architecture is shown in Figure -1. Broker Manager (BM) collects the various levels of services offered by cloud service providers based on their different performance through broker learning algorithms. Brokers manage the cloud service resources, BM communicates with brokers and short list the providers. Broker based Learning Algorithm (BLA) is used to study the workload of the providers, necessity tasks of users and requirement of resources.

Differential service module in federated architecture helps to identify the category of the user accessing the service either belongs to SLA or non-SLA with the help of the information available in Profile Manager. Non-SLA requests are not considered for resource computation until there is any request that belongs to SLA in the queue [7]. Instead of using this strict differential treatment, weighted Turned Queuing scheduling (WTQS) is proposed for differentiating and managing the requests fairly without starvation

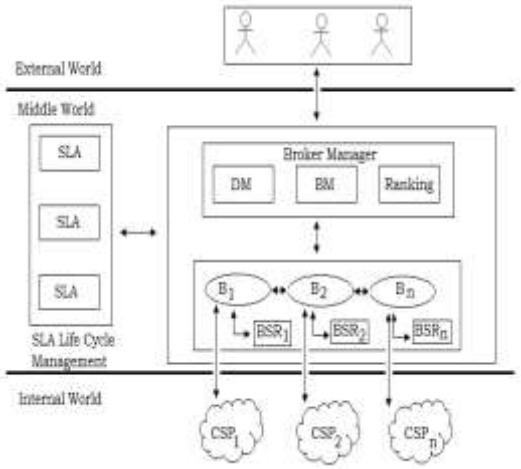

Figure 1: Customized Federated Architecture

. Two queues are maintained at the application level and initially weight is assigned for the queue based on the priority. Weight denotes the number of requests that considered for computation continuously from that queue. Later, the next queue requests are computed and vice versa. Cloud traffic is unpredictable and rush in nature. Hence, the value of the weight assigned may be turned dynamically either increased or decreased depends on the number of requests in that queue. When the number requests in queue is higher than normal, and then the weight to that queue is increased. The number of requests in the i^{th} queue is 'N_i'. Let us see this example, the request in the queues are 35 and 20 respectively. Then, deviation of the queue is calculated as Di = (2 * 35)/55 = 1.272(>1) and D_j = (2 * 20)/55 = 0.727(<1). As given in the example, the new weights of the queues are 44 and 14. It is computed from the algorithm in step 3. The summary of the weighted Turned Queuing scheduling is given as below

Step 1: Compute the number of requests in the queues.
Step 2: Calculate the deviation (D) of the queues using the formula, Di= (n * R_i)/ N .
'n' refers the number of queues. N denotes the total number of requests in the queues. R_i refers the number of requests in that queue.
Step 3: Calculate the new weight for the queue as
New_ $weight_i$ =.Old _$weight_i$ * D_i

3.1 Discovery of Service Providers

Cloud provider selection algorithm uses the quality metrics according to the Service Measurement Index (SMI) , short list the matched providers depends on the SLA and functional requirements. Let CP= {CP1, CP_2….CP_n} are the list of cloud providers in the Federated Cloud (FC). Let CB= {CB_1, CB_2….CB_n} are the cloud brokers that connected CP to the Cloud Manager (CM) in the proposed federated cloud architecture. Cloud broker considered the list of QoS indicators Q_i = {Q1, Q2, Q3….Q_N} for the service requests submitted by the user, broker initiated the processing and short listed the providers based on the value for the quality indicators assured. Then apply ranking on the short listed providers using Fuzzy based logic sets approach. In order to normalize the value of QoS indicators, the following are considered such as QoS metrics are measured uniform, qualities of the providers are analyzed using uniform index and assign threshold for the quality indicators based on the priority of it. The matching of provider is identified by the representation of the given set

MP = {QI, FA, RCP, CCP, SLAF} ……. (1)

MP denotes Matching provider for the service. QI is the list of Quality Indicator recognized by the SMI. FA discuss the functional requirements.RCP refers the resource demand by the service and released by the provider. SLAF means Service Level Agreement Factor, it is computed from the RCP.Cloud providers are clustered based on the type of service referred as Clustered Cloud Providers (CCP).The functionality of selection provider discovery is shown in Figure 2. Information such as user desired performance, corresponding price are registered in the Profile Manager and broker calculates the ratio of the desired performance to price and update the value in the registry of Broker Manager.

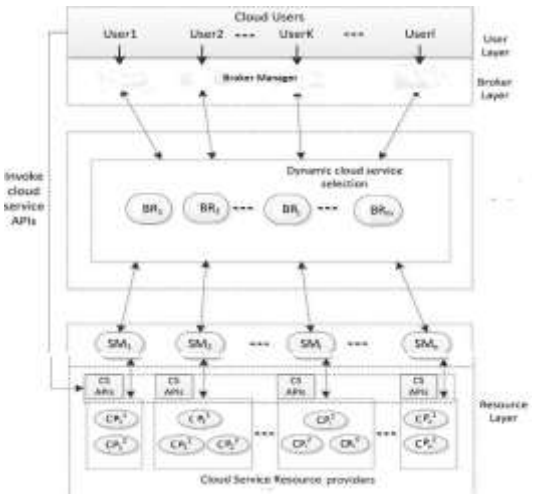

Figure: 2 Discovery of service provider in Federated Architecture

User layer consists of users accessing the cloud services. Broker layer performs the selection of providers for the user. It consists of Broker Manager, brokers connected with providers are clustered based on the service levels, performance and cost. Broker registry in broker manages information about the provider and helps to select the matching provider based on the equation 1. Broker Manager shortlisted the cloud providers and rank it using Fuzzy Logic set. Resource layer comprises of cloud providers, mapping with broker using Service Mapping (SM). SM can help the respective broker register the status of its connected provider in its registry including the failures of some services. Each provider defines API (Application Programming Interface) as means invoked by broker and used after finishing the process of cloud service selection. Cloud providers are clustered based on the level of service group, the number of available and matched providers are shortlisted for ranking using fuzzy logic set. The detail algorithm for cloud service provider selection is given below

Input: Registering and monitoring the availability of providers for selection.

Output: short listed provider for ranking.

1: SLA-Value= Max-Value; /*Register the value of SLA */
2. If there is any cloud providers register for the selection then
3. Broadcast the message from Broker Manager to the Brokers .
4. for each $Broker_i$ and i ∈ [1,n] do
5. $Broker_i$ communicate with the provider
5.1 compute C-SLA-Valuej← available (performance, security, usability, cost)
5.2 update the value $BrokerRegistry_{i,j}$← C-SLA-$Value_j$;
5.3 Invoke Broker-Cluster algorithm
5.4 Study the C-SLA-$Value_j$ in broker information registry and form $Broker_j$ as clustered.
5.5 Sends a register message from the $broker_j$ to Broker Manager along with C-SLA- $Value_j$;
5.6 The C-SLA-$Value_j$ is updated in the table information of Broker Manager.
Endfor
6. At Broker Manager, compare if SLA-Value >C-SLA-Value then
7: Reject that provider, unsatisfied the SLA, confirm message is send to the broker for its unavailability in the selection list.
8 else
9 send confirm message to the broker for its availability in the selection list.
10. end if
11. end for
12endfor
13 endif
14. If cloud $provider_i$ is found to be a failure, the information is registered in the
$BrokerRegistry_i$.
15 Auto message is send by the broker to Broker Manager
16. Update the status as unavailable for the selection.
17. end if

Figure 3: Service Selection Algorithm

3.2 Ranking of providers using Fuzzy Logic Set

Classical set theory requires that each element of a set included entirely within the set. Fuzzy set theory, a generalization of classical set theory, allows set elements to have partial membership and therefore allows representation of imprecise and qualitative information in an exact manner [14]. There are numerous methods for establishing the proportion of membership between two adjoining sets. The appropriate method is determined by the context of a particular application. Sigmoid shaped membership function is used to rank the cloud providers based on the following metrics such as service response time, sustainability, suitability, interoperability, availability, reliability, stability and cost. Service response time is computed by means of how fast the service/resources can be assigned for usage. Membership function is mapped to a membership value between 0 and 1. Sustainability refers the environmental impact of the cloud service used. Suitability indicates the requirement of user met by the cloud provider. Accuracy denotes the service functionalities measures to the user's actual values when using a service compared to the expected values. Interoperability is defined as the ability of a service to interact with other services offered either by the same cloud provider or other providers. Availability refers the percentage of time a user can access the service. Reliability denotes how a service operates without failure during a given time and condition. Adaptability means the ability of the service provider to adjust changes in services based on user requests. The effect of the sigmoidal shaped membership function is to provide the maximum separation between those serials in the middle of the ranking system, while those serials at either extreme are bunched together closely.

To propose ranking mechanism based on Fuzzy set approach having three general phases such as

problem decomposition, judgment of priorities and aggregation of these priorities. Fuzzy set may be combined by some simple rules. For example, the intersection of sets A and B is defined to be the minimum of the two fuzzy set membership functions while the union of sets A and B is defined to be the maximum of the two fuzzy membership functions. The following membership fuzzy set function used is given as below

Fuzzy membership = 1- 2 $(\frac{(x-\alpha)}{(¥-\alpha)})^2$ for ∞<x<¥ ----------(1)

Fuzzy membership = 2 $(\frac{(x-\alpha)}{(¥-\alpha)})^2$

for β<x<¥ ---------- (2)

To rank the service providers, the service functionality attributes are classified into three categories such as class A, class B and class C. Class A refers high level attributes such as accountability, assurance, security and privacy. Class B refers next level attributes such as usability, reliability and Interoperability. Class C denotes low level attributes such as user interest, stability, Cost, throughput and efficiency. Broker is responsible for interaction with users and understanding their request needs. Ranking system considered two aspects such as (i) the service quality ranking based on Fuzzy set and (b) the final ranking based on the cost and quality ranking. Each attributes are combined with weight functions and become easy to ensure the achievement of the best compromise solution based on the objective function. Ranking of Cloud services is one of the most challenging tasks in the framework of cloud. The Ranking System computes the relative ranking values of various Cloud services based on the QoS requirements of the user and features of the Cloud services. To calculate the selection of ranking the service provider using two distinct threshold values, then recalculated using a fuzzy set membership function to assign the membership values for each of the individual cloud provider ranking criteria and then used fuzzy composition rules to combine these data. Finally, the overall ranking of the cloud providers are considering by the Class C level attributes.

Cloud provider selection model is based on three steps of evaluation. First step is to identify the suitability of each service provider for the service render by the user. Suitability evaluation carried out by considering to reducing the effect of any particular measure in Class A. In second step, confirms that provider can extend services to the user render service request. Third step compare the cost and list the service providers. Cloud providers are selected based on the overall and individual cut off threshold values of the attributes considered for evaluation.

4 Simulation Results and Discussions

Simulation experiments were implemented on the JADE 4.3.0 platform [14] and on a computer whose configuration was an Intel Core i5-3337UCPU 1.80 GHz, 4.0GB RAM, Windows 7 (64 bits) operating system, Service Pack 1.Average response time and throughput was computed and the performance was also analyzed. The parameters considered for the simulation are number of users, number of cloud service providers, deadline of tasks etc. The execution time for each task is assigned randomly between 0.1ms to 0.5ms. Number of users considered are 1000, 5000 and 10000 at a time. Number of service providers available is fixed as 10, and deadline for each request is fixed as 0.5ms. Every cloud service provider has 50 computing hosts and a time-shared VM scheduler. Cloud broker on behalf of user request consist of 256MB of memory, 1GB of storage, 1 CPU, and time-shared Cloudlet scheduler. The broker requests instantiation of 25 VMs and associates one Cloudlet to each VM to be executed. There are two experiments were conducted and performance is analyzed with existing approaches.

The experimental results prove that the proposed scheduling algorithm performs better in terms of average response time. The average response time using Strict Differentiated model (DM) and WTQS is shown in Table 1.

Table 1. Average response time of the proposed architecture

Number of Users			Differentiated Module (ms)	WTQS (ms)
1000	SLA Member	400	0.32	0.28
	SLA Non-member	600	0.90	0.82
5000	SLA Member	3000	0.37	0.32
	SLA Non-member	2000	0.84	0.73
10000	SLA Member	6000	0.54	0.4
	SLA Non-member	4000	1.10	0.96

The second experiment results analyze the success rate of the selection algorithm. In nature, there may be failure of cloud services in the process

of selection algorithm, the selected provider by the proposed algorithm cannot be completely successful, but the successful rate of cloud service selections is considered as a performance measure to evaluate it. The successful selection rate is defined as the ratio between number of successful selections and the total number of selections.

$$\text{Successful Selection Rate (SSR)} = N_{suc} / N_{TOT}$$

In other words, N_{suc} denotes the exchanges of messages between user and provider. In experiment, the value of N_{suc} is decided based on the average rate of throughput. N_{TOT} refers the number of cloud selections attempted. The probability value is greater than 0.5 then the SSR is efficient. In experiment, there are 4 cloud selections and 25 messages were exchanged between user and provider. It is applied in the above equation and c the value of the probability of SSR is 0.625. Hence, it is concluded that the selection rate of cloud provider for the service is effective and efficient by the ranking algorithm.

5 CONCLUSION

Cloud computing has become an important technology for outsourcing various resource needs of organizations. Proposed federated cloud mechanism helps to resolve the difficulties of selecting the optimal cloud provider for the service. The issue of starvation is resolved by introducing a scheduling algorithm called WTSQ. The shortlisted providers are ranked based on fuzzy logic set and depends on the availability, the top ranked provider is assigned for the tasks. The performance was compared and found that it is better than the existing federated cloud architecture.

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