Auction Model Using RR Approach for SLA Based Resource Provisioning in Multi-Cloud Environment

Naela Rizvi [#1], Prashant Pranav [#2], Bibhav Raj[#3], Sanchita Paul[*4]

[# 1,2,3] ME Scholars, Department of CSE, Birla Institute of Technology, Mesra, Jharkhand, India
[1] naelarizvi92@gmail.com
[2] prashantpranav19@gmail.com
[3] raj.bibhav@gmail.com

[* 4] Assistant Professor, Department of CSE, Birla Institute of Technology, Mesra, Jharkhand, India
[4] sanchita07@gmail.com

Abstract— Cloud Computing is rapidly getting momentum as an alternative to traditional IT Infrastructure. It is a way to share resources over a network in order to achieve coherence and economic of scale and aims at maximizing the effectiveness of the shared resources. The resources available in Cloud can not only be shared by multiple users but are facilitated to reallocate with every demand. So, there has always been focus on best techniques to provision the available resources in the Cloud.

Cloud providers receive requests for resources from the users and allocate the resources by creating appropriate number of Virtual Machines (VMs). There are many provisioning techniques viz. Static Provisioning, Dynamic provisioning, etc. Apart from these provisioning techniques some parameters are to be considered such as minimize cost, resource maximization, response time, less SLA Violation etc in order to provision resources well. Cloud Resource provisioning mechanisms must follow some SLAs (Service Level Agreements) in order to abide by customers demand properly. There have been many articles which have taken the issue of SLA but still confusion remains about the importance of SLAs. SLAs typically are defined in terms of Mean Time to Failure (MTTF), Mean Time to Recover (MTTR), etc.

This paper is a survey paper on various literatures published on Cloud Computing Resource Provisioning Techniques some of which takes SLA into account. A detailed description of some of the papers related to this topic is presented here.

Keyword-Cloud, Cloud Computing, Resources, SLA Oriented, Round Robin, Auction model, FCFS

I. INTRODUCTION

Cloud computing is a new computing paradigm which gained momentum in late of 2007. Cloud computing refers to delivery of resources on internet. Because of utility based nature, cloud offers computational services whenever users need it. Thus transferring to more commoditised utilities like water, gas, electricity etc. Users pay for whatever they use there is no need to purchase whole infrastructure. Computing resources are distributed worldwide so that companies are able to access their applications and services anytime from anywhere. Due to reduced computational cost, high degree of reliability and flexibility cloud has become one of the exciting technologies.

A. Different Types of Cloud Environment

1) *Public Cloud:* Public Clouds can be used by customers through Cloud service providers like Amazon AWS, Google and Microsoft who solely controls the infrastructure and allow customers to access the service over the internet. All customers have access to same infrastructure pool and hence the security and availability variances are limited. Each individual Client operates at low cost and hence customers are benefited in terms of cost of services. Public Clouds can be used for developing and testing codes online, working in a group project, etc.
2) *Private Cloud:* In case of Private Cloud, the access to Cloud infrastructure is limited to a single organization. Applications can be hosted by organizations in the Cloud while still preserving the security of data hosted. It can be hosted internally or externally and is not shared by any other organization. Private Clouds are more expensive but at the same time more secure as compared to other Cloud environments. Private Clouds can be used when one need data consistency for different services, for making the data centres more efficient, etc.
3) *Community Cloud:* In a Community Cloud, several organizations participate and the data is shared among all of them. The management of Community Clouds is in the hands of either all the participating organizations or a third party service provider. It gives the participating organization the feel of Public Clouds with added advantage of security of data. Also policy compliances associated with Private Clouds

can be privileged in a Community Cloud. Community Clouds can be used when there is a need to share resources between government organization within a state, or for a group of hospitals or clinics.

4) *Hybrid Cloud:* Hybrids Clouds are generally a mixture of two or more clouds viz. Public Clouds, Private Clouds or Community Clouds. The leveraging of third party service provider can be either done as a whole or partially. It is necessary to keep track of security platforms of multiple clouds in order to keep data secure. Hybrid Clouds can be used in cases when the use of SaaS application is required but is not implemented due to the issue of security, or when for a organization it is required to use Private Cloud internally but at the same time providing Public Clouds for services.

B. Various Types of Computing Environments

1) *Grid Computing:* In grid computing jobs are executed across a distributed set of processors. Grid computing divides a program into various subprograms. Each subprogram is assigned to different individual processors where each processor executes the subprogram and give results. If due to some reason a processor fails to execute the subprogram then the subprogram is shifted to another processor and hence result is not affected. Every node is considered as independent entity in grid computing.

2) *Cluster Computing:* Cluster computing provides a platform where various off-shelf computers connected with high speed networks to form a single powerful super computer. Cluster computing is not applicable only for Scientific and Engineering applications but also provide a great extent of benefits to Business Applications. Its architecture consists of a cluster which is a type of parallel or distributed computer system having interconnected standalone computers. These computers work as single integrated computing resources which consume only single resource pool. Computers on clusters have similar hardware as well as same software all are attached in a tightly coupled fashion.

3) *Cloud Computing:* Cloud computing is the delivery of applications, platform and infrastructure as a service over the internet which is accessible by users. Cloud is a collection of various resources like network, storage, software, database servers which are distributed worldwide so that they are accessible to users. User uses the services on rental basis and pay only for that.

C. Service Models of Cloud Computing

1) *Infrastructure-as-a-Service (IaaS)***:**

- Resources are provided as a service.
- Services like storage, bandwidth, database management and computing capabilities are provided on demand.
- Include multiple users on a single hardware
- Examples are Amazon Web services, GoGrid etc.

2) *Platform-as-a-Service (PaaS):*

- Platforms are provided for building and executing custom based web applications.
- Provides all the facilities which are required during a complete lifecycle of building and developing applications with no software downloads or installations for developers
- Web based tools are used to create, modify, test and deploy different UI Scenarios.
- Billing and Subscriptions are also handled using tools.
- Examples are Microsoft Azure and sales force's Force.com

3) *Software-as-a-Service (SaaS):*

- Traditionally Software As a Product (SaaP),a software distribution model is used where software is purchased and then it was installed on personal computers. Now software is distributed as a service by using SaaS model where applications are hosted by Service Provider which is made available to customer through internet.
- SaaS Applications are designed for users and delivered over the internet.
- Software is delivered as "One –to-many" model.
- Software is managed from central location so there is no need of users to handle and control infrastructure like network, operating system, servers, storage etc
- Companies that offer SaaS are Google, Microsoft, Zoho etc.

D. Benefits of Cloud Computing

Some of the benefits attributed to the use of Cloud Computing are:

1) *Reduced Cost:* Pay As per Usage is used as a billing model therefore user need not to purchase the infrastructure. Initial expense and recurring expenses are much lower than traditional approach.

2) *Increased Storage*: Due to massive infrastructure provided by cloud storage and maintenance of large volumes of data become quite easy.

3) *Increased Manageability***:** A simplified and enhanced management of resources, infrastructures and SLA backed agreements are provided by cloud computing.

Section 2 gives a short description of Resource Provisioning with its two techniques, parameters and challenges. A detailed architecture of SLA Based Resource Provisioning Techniques is presented in section 3. Comparison of various literatures published on this topic minutely is discussed in section 4. Section 5 gives the architectural details of some of the models used in algorithms of different resource provisioning techniques. Finally, conclusion and future works which can be done in this topic are discussed in section 6.

II. RESOURCE PROVISIONING IN CLOUD COMPUTING

In cloud computing resource provisioning is the process of assigning resources to the needed applications over the internet. Resource Provisioning means the selection, deployment and runtime management of software and hardware resources. Resource provisioning should be done in an efficient manner such that it avoid Service Level Agreement (SLA) violation by meeting Quality Of Service (QoS) parameters such as availability, response time, throughput, security , etc.

In grid environment, resources are accessed based on a queuing model which provides best-effort QoS. Jobs are put in the queue till the resources the jobs require are freed. As jobs have to wait for resources to become available, this approach results in long delay. These delays vary according to the number of jobs any application have. To improve QoS for workflow application (more number of jobs) a model for resource allocation based on provisioning can be used which allows a single user to gain total control of the resources for a given period. This minimizes queuing delay. Provisioning is more complex than queuing in the way it requires more sophisticated resource allocation decisions. Two policies which guide these decisions are:

A. Static Provisioning:

In static provision, the application allocates all resources required for the computation before any jobs are submitted, and releases the resources after all the jobs have finished. This is suitable for those applications which have predictable and constant demand. In this provisioning, users have contract with providers for services and Cloud Providers allocate maximum resources to prevent SLA Violation. But this method is not effective because a lot of resources are wasted because workloads are not peaked and both users and providers incur loss.

B. Dynamic Provisioning:

In dynamic provisioning resources are allocated by the system at runtime. This allows the pool of available resources to grow and shrink according to the changing needs of the application. This is applicable for those applications which have varying demand. With this provisioning Provider allocate resources only when needed and then remove resources when not in use and allocate these not used resources to fulfil another demand. Costumers are charged on pay per use basis. This provisioning technique provides maximisation of profit for both user and provider.

C. Parameters of Resource Provisioning

Various parameters which define resource provisioning are:

1) *Minimize Cost:* From the cloud users point of view cost should be minimized.
2) *Resource Maximization:* It should be maximized for cloud service providers.
3) *Response Time:* Algorithms must take minimal time to complete execution.
4) *Reduced SLA Violation:* SLA must be followed strictly by the algorithms designed.
5) *Reduced Power Consumption:* VMs placement and migration technique must consume less power.
6) *Fault Tolerant:* Algorithms should work continuously in spite of failure of nodes.

D. Challenges of Resource Provisioning

Dynamic resource Provisioning has various advantages but still it is not free from challenges and issues. Provisioning should be done in an efficient manner and in an appropriate time. Too early provisioning will waste both resources and money. Delay provisioning causes SLA violations. Resource should be provisioned in such a way that over provisioning and under provisioning should be avoided. Various techniques have been proposed but still exact prediction is not possible.

Another issue that come across is to keep users satisfied with respect to Quality of Service (QoS). Resource provisioning takes SLA into consideration for providing services to users. It is an initial agreement between User and Provider which ensure user's Quality of Service Parameters like response time, availability, reliability etc. So provisioning should be done without SLA violation and starve at meeting the QoS.

III. System Architecture Supporting SLA Based Resource Provisioning in Cloud

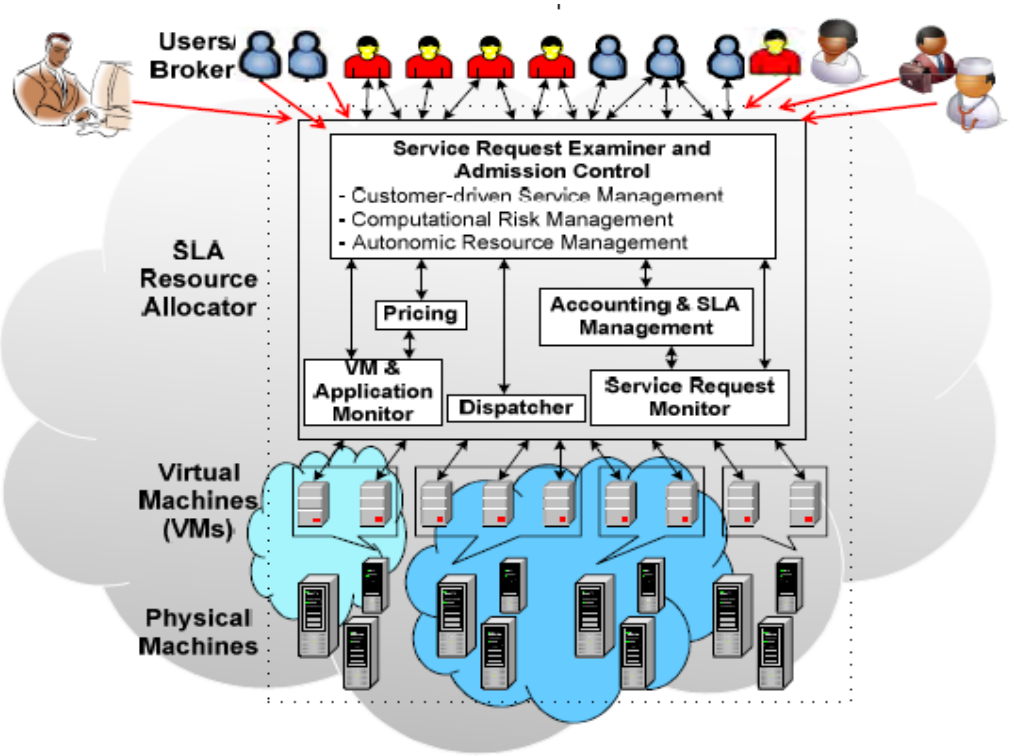

Fig. 1. System Architecture Supporting SLA Oriented Resource Provisioning in Cloud Computing [Taken from 1]

There are Four Main components

User/Broker: Users interact with cloud management System through Brokers who on the behalf of users submit request to cloud.

SLA Resource Allocator: It Is an interface between cloud computing infrastructure and users/Brokers.

Service Request Examiner and Admission Control: When users submit request, firstly it is interpreted by Service Request Examiner who examine QoS requirement and then decide whether to accept or reject request. It avoids over provisioning and under provisioning of resources and avoids SLA violations. In order to make effective decision it retrieves latest update regarding resource availability.

Pricing: It manages service demand and maximise profit of cloud providers.

Accounting and SLA Management: It keeps tracks of SLA of users with cloud providers. Accounting mechanisms keep details of actual usage of resources and then compute final cost which is charged from users.

VM and Application Monitor: VM monitor mechanism keeps track of the availability of VMS whereas

Dispatcher: It is responsible to deploy the application on appropriate virtual machines and also create virtual machine image.

Service Request Monitor: It keeps records of the execution progress of service request

Virtual Machines: Multiple virtual machines are created to meet service request on the same physical machines. Since each VMs are completely isolated from another so multiple VMs can run concurrently.

Physical Machines: Multiple Servers are hosted on data centres to provide resources to meet demand.

IV. Related Work

There are many resource provisioning techniques detailed so far. These were analyzed on various aspects. [1, 6, 7, 8, 11, 12] are more SLA centric. The techniques of [2, 7, and 11] focus on reducing the application and execution time while those discussed in [3 and 13] reduce energy consumption. [5 and 12] explains better ways for optimizing QoS while [1, 9 and 13] explains cost optimization techniques. Profit is the main concern of techniques in [9, 10 and 12]. Resource utilization in a better way is discussed in [9 and 12].

A. Existing Model

The existing job allocation algorithm is discussed in [12]. It uses an auction based policy for job allocation using **Job Allocation with SLA (JAS)** algorithm. Some clouds are selected in this model out of which a few are made the bidders and rest vendors. When a job comes the auction model looks among bidders for the

availability of resources. So, the availability SLA requirement of a job is checked. This model uses FCFS approach for job scheduling. If the bidders have enough resources, the job is executed between them; else they go for auction and call other cloud vendors to bid for the purpose of execution of a job. The cloud vendors have their fixed initial rent which the bidder will have to pay in order to have their services. The vendor with lowest bid is selected and the job is executed in that vendor. If the vendor fails to execute the job within the specified time limit, it will have to pay penalty.

V. THE SYSTEM MODEL

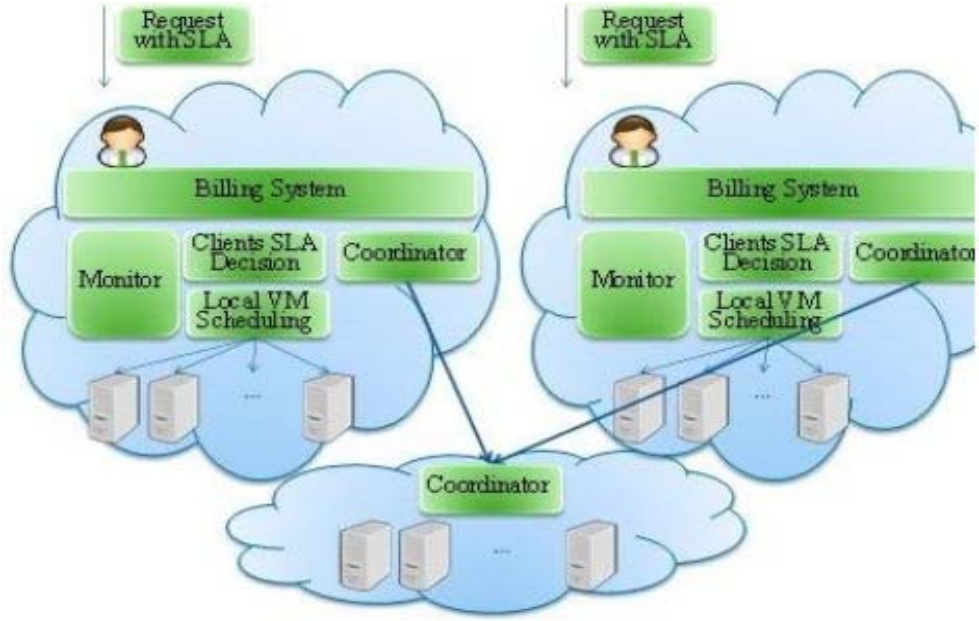

Fig. 2. System Model Supporting Auction Based SLA Oriented Resource Provisioning in Cloud Computing [Taken from 12]

When a client submit more jobs to cloud provider, many times cloud provider don't have enough resources to fulfil their demand. In order to fulfil request cloud provider have to lease resources from other vendors. In order to lease resources we have proposed an auction model to perform dynamic provisioning of resource.

Here the Coordinator performs the main function. It provides communication such as sending information to other cloud about resource status; compete for resources with other bidders. The system consists of resource layer which include various heterogeneous physical and virtual machines. Monitor monitors the availability of resources and update resource status to increase provisioning efficiency. To ensure profit bidding time should be minimum .After bidding coordinator submit the job to the vendor.

A flowchart is shown here which describes the working of system model

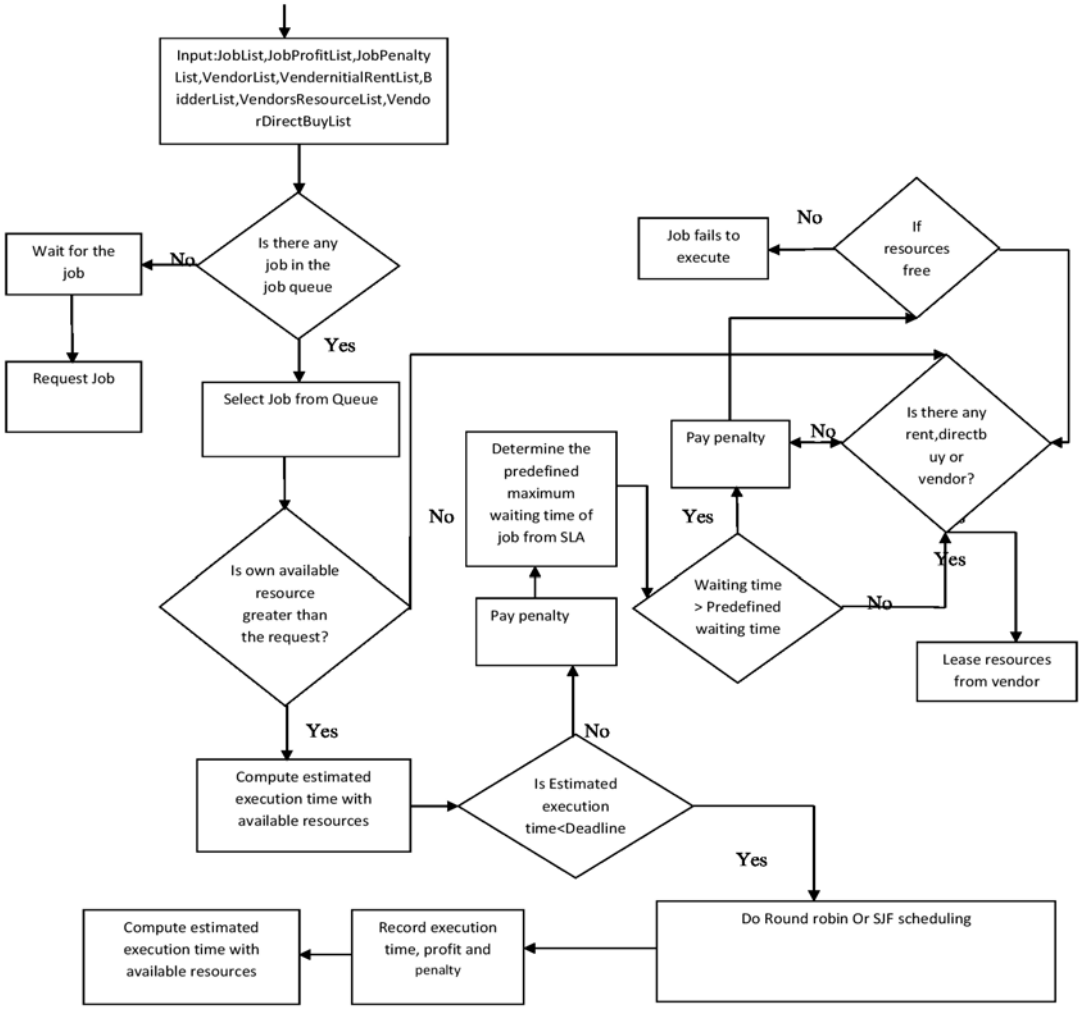

Fig. 3. Flow Chart of Proposed Model

B. Proposed Job Allocation with SLA (JAS): Algorithm

```
Input:CloudletList,CloudletProfitList,CloudPenaltyLis
t,VendorsList,VendorsInitialPricingList,
BidderList,VendorsResourcesList,VendorsDirectBuyList

Return:Profit, Penalty, Execution time, Rent,
Directbuyprice, Vendors

CloudletList {j1, j2, …, jN};
CloudletProfitList {p1, p2, …, pN};
CloudletPenaltyList {l1, l2, …, lN};
Vendors List {V1, V2, …, VN};
VendorsIPList {VIR1, VIR2, …, VIRN};
VendorsResourceList {VR1, VR2, …,
VRN};
Bidder List {B1, B2, …, BN};
VendorsDirectBuyList {VDB1, VDB2, …,
VDBN};
for Cloudlets from j1 to jN in Cloudlet List
do {
if (own available resources >= request)
then
Calculate estimated execution time
If (estimated execution time =< deadline)
RoundRobin(Scheduling);
record execution time;
profit = CloudletProfit
else
Pay Penalty
Determine the predefined maximum
waiting time of job from SLA.
while (waiting time > predefined
waiting time)
do {
Pay Penalty
}
else
call x = {rent, direct buy price, vendors}
if (x == null) then
penalty = CloudletPenalty;
end if
end if }
return profit, penalty, execution time, rent,
direct buy price, vendors
```

C. Auction Model: Algorithm [Taken from 12]

```
Return: Rent, Direct Buy Price, Vendors

for VR from VR1 to VRN in VRList do{
sort(VRN); more to less
re-order (VRN); }
for VDB from VDB1 to VDBN in VDBList do{
sort(VDBN); low to high
re-order (VDBN); }
for ( i=0; i<=N; i++) {
VIR [i];
rent = VIR [i] + random*value;
if (Bidder not in BidderList) then
pay VIR[i] to Vendorsi;
submit jobi to Vendorsi;
else
if (failure < threshold) then
While ( rent <= other bid highest rent )do {
rent = bid highest rent + random*value;
If ( rent > job's profit) then
rent = 0;
failure += 1;
allow=0;
break;
else
allow=1;
break;
end if }
else
allow=2;
end
if (allow == 1) then
pay rent to vendorsi;
submit jobs to vendorsi;
end if }
if (allow == 2) then
for ( i=0; i<=N; i++){
pay direct buy price to vendorsi;
submit jobs to vendorsi;}
end if
return rent, direct buy price, vendors
```

When a user submits the job to cloud vendor, cloud vendor will check whether available resources are enough or not to fulfil the demand. If available resources are sufficient enough then job's estimated execution time is calculated .If estimated execution time is less than deadline then Job is scheduled by using round-robin scheduling policy and then profit is calculated. Otherwise Provider has to pay penalty when execution time exceeds deadline as SLA is violated. When resources are not available then auction is performed by bidders. Before doing auction, algorithm check weather waiting time exceeds the predefined waiting time if so then penalty is charged against cloud provider. So in line (18-22) of JAS Algorithm we are trying to reduce SLA violation by minimizing waiting time of job. If predefined waiting time of job is less than the actual waiting time mentioned in SLA then cloud provider have to pay penalty again due to violating SLA. After that, Bidder

performs bidding to select appropriate vendor. When bidding is won job is submitted to the winner vendor. If there is no bidder then cloud provider directly buy resources from vendors.

VI. PERFORMANCE ANALYSIS USING A CASE STUDY

We tried to simulate our work in CloudSim software. For this we created seven clouds with two working as bidders (Cloud 2 and Cloud 3). Suppose that all the clouds will have specific characteristic as CPU, memory and storage. The seven clouds are listed below:

TABLE I. Specification Of Seven Clouds

Clouds	CPU	Memory	Storage
Cloud 1	1	4 GB	150 G
Cloud 2	1	2GB	100 G
Cloud 3	2	2 GB	120 G
Cloud 4	1	2 GB	110 G
Cloud 5	1	2 GB	90 G
Cloud 6	2	4 GB	100 G
Cloud 7	2	4 GB	200 G

There are 10 jobs to be executed on both the bidders. All the jobs have specific characteristics and requirement. Some need more storage while other more memory. Each job has deadline, profit, penalty and others among the variables. All the cloud vendors have their initial rents and resource utilization. The seven clouds hosts one or more virtual machines on them in which the jobs are executed. Now when the jobs come, the bidders execute them on their specific VMs. If the bidders fall sort of resources, they go for auction among the available vendors. First the bidders check for the availability of resources among them, this condition satisfies the SLA with respect to availability. Second if resources are not available with the bidders, they lease resources from vendors and as such takes into consideration the waiting time of a job. This condition satisfies the reduced waiting time SLA requirement of a job. Also by leasing resources, the jobs are taught to be executed before their respective deadlines. So, deadline SLA parameter is met. Suppose 10 jobs arrive with different requirements. The requirements of the jobs with their ids are shown below:

TABLE II. Specification Of Ten Jobs

Job Id	Processing Unit Required	RAM	Storage
J 1	1	2 GB	70 G
J 2	1	2 GB	50 G
J 3	1	2 GB	30 G
J 4	1	4 GB	150 G
J 5	2	4 GB	125 G
J 6	2	2 GB	110 G
J 7	2	4 GB	100 G
J 8	1	4 GB	90 G
J 9	1	2 GB	120 G
J 10	2	2 GB	115 G

The proposed model is better than the existing auction model which uses JAS algorithm because it takes three SLA into consideration viz. Availability, deadline and waiting time. It reduces the waiting time as well as the resources are always available due to auction mechanism. Further we are trying to implement it using round robin scheduling. This ensures that no job has to wait longer for their execution.

To elaborate it further, let us define the constraints associated with each job. We define the deadline, total execution time, predefined waiting time, actual waiting time and penalty. Deadline is the time in which a job is taught to be executed successfully. Total execution time is the actual time of execution of a job including the time for which the job remains idle. Predefined waiting time is the waiting time confronts with the customer in SLA and actual waiting time is the time for which the job actually waits for resources to be available. Penalty is the cost which a cloud provider will have to pay if it does not complete the job in time. We have taken to pay Rs

10 as a penalty, if the job exceeds the deadline by 1 ms. Similarly, if the job exceeds the predefined waiting time by 1 ms, the provider will have to pay a penalty of Rs 10. All time are in Millisecond (ms) and we have used a round robin scheduling policy with time quantum=10 ms.We have also done the calculation of FCFS scheduling and have compared it with our model.

TABLE III. Comparison of Round Robin and FCFS

Job Id	Arrival Time	Deadline	Total Execution Time		Predefined Waiting Time	Actual Waiting Time		Penalty	
			Round Robin	FCFS		Round Robin	FCFS	Round Robin	FCFS
J 1	0	95	100	70	40	30	0	50	0
J 2	2	110	120	50	65	70	0	150	0
J 3	5	70	55	95	30	25	65	0	600
J 4	8	140	140	150	100	90	0	0	100
J 5	10	130	125	125	40	0	0	0	0
J 6	12	200	250	150	130	140	40	600	0
J 7	15	200	190	100	50	90	0	400	0
J 8	16	200	162	232	80	82	142	20	940
J 9	19	250	263	263	150	130	143	130	130
J 10	22	210	208	208	100	90	115	0	150
					Total Penalty			1350	1920

When Job 1 arrives at time 0, it gets the resources from first bidder and is executed for 10 ms. Then after Job 2 arrives and it goes to the second bidder and is executed for 10 ms. Job 1 continues to execute in the first bidder till 10 ms. When Job 3 arrives, bidder one has executed Job1 for its time slice and so Job 3 is executed on bidder 1. When Job 4 arrives both the bidders fall sort of resources and so auction mechanism is called. All the vendors bid for executing the job and Cloud 1 wins the auction and hence this job is moved to cloud 1.

So, as can be seen from table, all jobs except job 10 are executed within the specified time limit. So, the vendors need not to pay penalty for that as Job 10 is executed in bidder. This scheme tends to decrease the waiting time and also intends at checking the availability of resources. Both the SLA metrics can be seen to be effectively met by using this algorithm. Similarly, Job 5 moves to Cloud 7.Job 2, Job 6 and Job 9 are scheduled on bidder 2 using round robin policy. When Job 7 arrives again the auction mechanism is called upon and Job 7 is hence moved to Cloud 6. Job 10 is also executed there in and Job 8 is moved to Cloud 1 where job 4 is already executing.

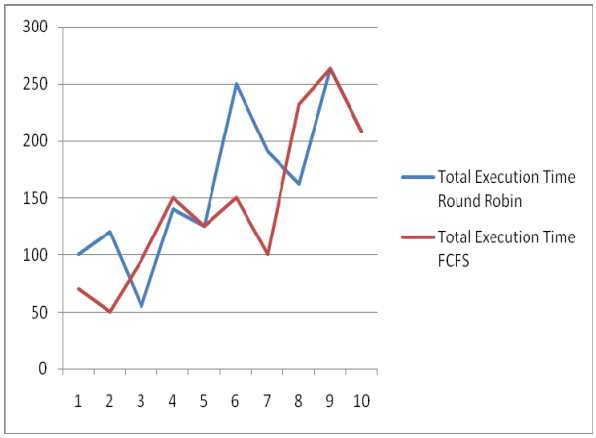

Figure 1

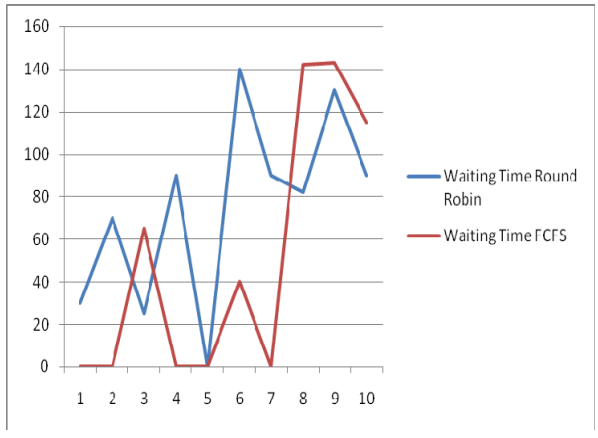

Figure 2

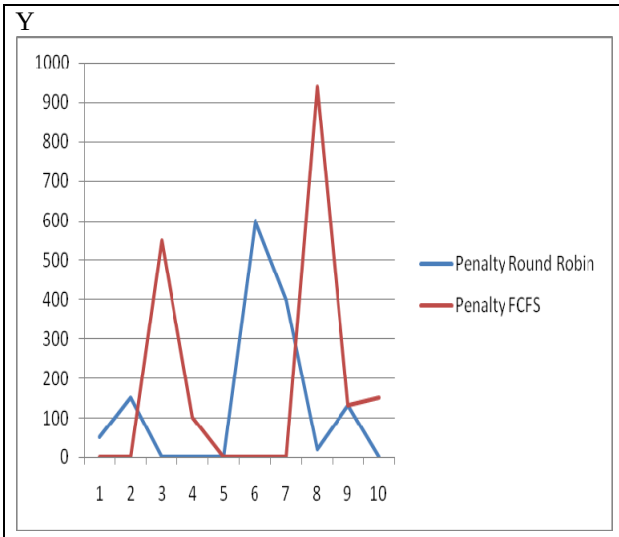

Figure 3

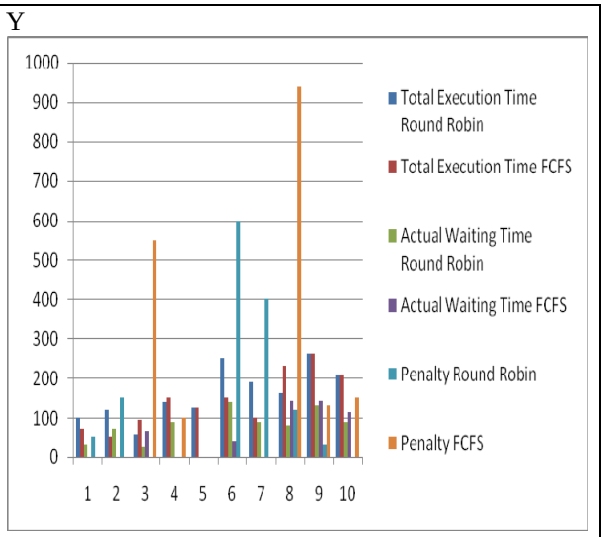

Figure 4

Fig. 4. Graphs Showing the Difference Between the Two Approaches. Figure 1 shows the relation between total execution time for both round robin and FCFS scheduling. Figure 2 depicts the relation between both in terms of waiting time while Figure 3 shows that in terms of penalty. Figure 4 shows the overall relation between these two policies.

VII. COCLUSION

As a conclusion, it can be said that after calculating the total execution time and waiting time for both the policies, we find that both compete adequately when deadline and predefined waiting time are considered. But, FCFS users will have to pay more penalties as compared to round robin users. Round robin gives better result when number of jobs in the queue is less and also it makes the resources more frequently available than FCFS. As a limitation, it can be said that round robin is not performing well when the number of jobs in the queue increase. So, in the future we will try to do implement it using other scheduling algorithms and try to compare which one is better.

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AUTHOR PROFILE

Naela Rizvi She is a ME-Software Engineering student from BIT, Mesra. She did her BE in Computer Science & Engineering from Radha Raman Institute of Technology and Science. She have a very good academic record.

Prashant Pranav He is a ME-Software Engineering student from BIT, Mesra. He did his B.Tech in Computer Science & Engineering from College of Engineering Bhubaneswar.

Bibhav Raj He is a MTech-Information Technology student from BIT, Mesra. He did his B.Tech in Computer Science & Engineering from Bengal College of Engineering and Technology

Sanchita Paul She is Assistant professor in CSE department of BIT, Mesra. Her specialization includes Cloud computing among others.