International Journal of Distributed and Cloud Computing
8 (1 & 2) 2020, 01-08
http://www.publishingindia.com/ijdcc

Significance of Admission Control Mechanism in Cloud Computing Environment

Nikky Ahuja[1*], Priyesh Kanungo[2] and Sumant Katiyal[3]
[1]Research Scholar, School of Computer Science and IT, Devi Ahilya Vishwavidyalaya, Indore, Madhya Pradesh, India. Email: ahuja_nikky@yahoo.co.in
[2]Professor, School of Computer Science and IT, Devi Ahilya Vishwavidyalaya, Indore, Madhya Pradesh, India. Email: priyeshkanungo@hotmail.com
[3]Professor, School of Electronics, Devi Ahilya Vishwavidyalaya, Indore, Madhya Pradesh, India. Email: sumant578@yahoo.com
*Corresponding Author

Abstract: While allocating the cloud's resources the most crucial task for any service provider is the fulfilment of SLA obligations, since, non-meeting of these obligations results in penalty cost that would ultimately increase the providers' cost and will also affect their customer's satisfaction level. This might further have an impact on the software services and may increase the administrative and resource management cost. The admission control mechanism can play a pivotal role in resolving this problem by acting as a guide for resource provisioning. Thus, one must make efforts for the establishment of a better admission control mechanism between SaaS and IaaS provider. The model and algorithm proposed in this paper is an effort to show the significance of admission control mechanism for a service provider during the process of resource allocation, so as to minimize SLA violation and it's after-effects. Findings of the simulation study show that the proposed model helps in the successful admission of tasks in Cloud, meeting QoS constraints defined in SLA.

Keywords: Admission control, Quality of Service (QoS), Service Level Agreement (SLA), Software as a Service (SaaS).

I. Introduction

Cloud Computing is a budding notion that apprehends the use of the internet for providing and administering services on pay-as-you-go model [1] [2]. Cloud is an organization of virtualized servers that facilitates the fulfilment of diverse resource demands of the user. Each and every service in an IaaS is considered as a set of Virtual machines (VMs) that are activated considering the pattern of their workflow each time a new user request arrives. Virtualization techniques are used in a cloud to facilitate the faultless positioning of the system's components which further simplifies the process of horizontal elasticity [3]. It helps in keeping a check over the system's performance for varying workloads. Also, horizontal elasticity helps in the addition or removal of duplicate VMs. The aim of admission controlling technique here is to ease the cloud performance and strengthen it. During the process of admission control, the IaaS provider considers both the basic computational and networking needs [4]. It also keeps an account of extra requirements that may arise in the run-time of the request. This makes the cloud system dynamic. In the majority of cases, these dynamic requirements are relatively large as compared to the initial requisition made, especially when multiple users are accessing the cloud resources with a high variation of a workflow.

This increases the requirement for the numbers of initiated VMs, which are added during the performance of the request. This makes it mandatory for the service provider to consider the dynamic nature of the cloud system when allocating the resources. Admission control mechanism helps the service provider in balancing the basic and dynamic resource requirement, and also in evaluating any possibility for the optimization of resources when accepting any service [5].

II. Admission Control with QoS Factors Consideration

In a cloud computing environment, the mechanism that acts as a guide for a SaaS provider as on how to prioritize tasks, applications, data flow or users to assure or meet the pre-decided level of performance is known as Quality of Service (QoS). It is one of the most important parameters that must be focused on cloud computing [6]. The standards set in QoS are frequent and are highly dependent on the final output, performance limitations and data loss rate of the application. But the major challenge faced during the fulfilment of QoS requirement is the provisioning of the resources. For the successful accomplishment of a cloud contract, it is really essential to get a thorough understanding of customer's Quality of Service (QoS) requirement and then allocating of the resources as per the users' demand. It is quite a challenging task for a service provider as they have to manage the entire request as well as

have to focus on the satisfaction of customers meeting their QoS requirements. For maintaining the QoS, a service provider is needed to give an immediate response to the customers so as to minimize request delay time [7]. This requires an effective and efficient admission control strategy that could help in the fulfilment of the basic purpose of SaaS provider. Admission control mechanism should be designed in such a way that the obligations of both, the user and the service provider are met [8]. This helps in satisfying their needs and also benefits them both.

For assuring that both the user and the service provider perform their responsibility efficiently, an agreement termed as SLA is made between them. SLA [9] is an agreement that creates a legal obligation between a service provider and user on the agreed terms of service including an implicit description of all the parameters defining a level of service, assurance of the quality. It also states the remedies for all the cases of agreement violations (if any). SLA is formed only after getting the consent of both the parties involved in the contract and is continued until the completion of all the jobs assigned by the user. The QoS constraints [10] [11] that must be fulfilled for the successful accomplishment of any service contract between the SaaS provider and the user are defined as:

Deadline: In this complex and dynamic business environment meeting of deadlines plays a pivotal role in the successful accomplishment of any cloud contract. The term deadline means the maximum time limit that is given by the client to the service provider for getting the expected service output.

Budget: The maximum limit of the amount that a client is ready to pay for the successful accomplishment of the task in the stipulated time limit is known as a budget. It also defines the amount which would be paid by the user for the renting of administrative services.

Penalty Rate Ratio: The cost incurred upon the violation of any of the term defined in SLA is termed as penalty rate ratio. It acts as a remedy for the client when the SaaS provider misses the given deadline.

Input File Size: The length of the file that contains information regarding the client and its service requirement.

Length of the Request: For the fulfilment of the user's resource-specific requirement, millions of instructions are needed to be executed. This represents the length of the cloud's service contract.

III. Literature Survey

Khoshkholghi *et al.* [12] have studied the issues of providing high-quality services to cloud service users and lowering the consumption of power in the data centre. Findings of the study show that proposed algorithms generates improved SLA guarantee up to 87% and a reduction of 28% in energy consumption as compared to conventional algorithms.

In the research work of He *et al.* [13], authors have proposed an innovative admission control mechanism, which they have named as EB-based admission control mechanism, for controlling the traffic of large volumes of concurrent resource request in a cloud computing environment. Performance evaluation of the proposed mechanism shows that a larger volume of flows could be accepted for higher delay constraint.

Choi and Lim [14] have evaluated resource provisioning strategies for SLA based cloud computing architecture. They have proposed a combinatorial auction system for the allocation of resources keeping in view the SLA constraints of the contract. Authors have suggested that the profit can be increased by reducing SLA violations and penalty cost associated with it. For cost reduction, while deciding winner for auction job urgency based deadline constraint of the service contract is examined. Authors have compared their proposed system with conventional methods and their test results show that the proposed system is more profitable and shows higher rates of successfully accomplished jobs.

For an increasing profit of cloud service providers and improving resource utilization, there is a need for effective and better admission control. This objective can be achieved by using vivid research methodologies which focuses on resource provisioning keeping in concern enhance profit and decrease makespan. Authors [11] have worked upon two different learning approaches i.e. SVM and ANN for achieving the objective of enhancing customer satisfaction level and proper resource provisioning. Experimental results show that proposed methodologies could achieve better admission control meeting customer satisfaction constraints.

Zhou and Hu [15] have presented a scheduling algorithm for tasks in the cloud that measures the minimum completion time for all assigned tasks to cloud's resources and then select minimum and maximum values to make pairs of minimum completion time. This process is continued until all tasks are scheduled. Authors have then compared their algorithm with min-min, max-min algorithms and have interpreted that for efficient task scheduling, apart from completion time we must also consider other factors like resources cost, energy consumption rate, resource utilization rate and average response time.

IV. System Model

This section describes a model of SaaS provider that comprises of the actors and components of admission control, scheduling and knowledge processing. Actors of this model consist of the service provider and the user, whereas the functions of the application layer and platform layer are the parts of the cloud system. Here user submits a request for software from the SaaS provider which consists of the description of his QoS requirements. In the next step, the platform layer utilizes the admission control mechanism and accepts a request or rejects it after doing the proper analysis. A request is filtered on the basis of the availability, price, storage capacity and load of the VMs. The decisions for admission control are based on its knowledge

collected from its knowledge processing component. On the basis of this decision, the allocation of resources is done by the scheduler. Fig. 1, shows a service model for SaaS providers in a Cloud Computing Environment consisting of three layers namely, infrastructure layer, platform layer and application layer to meet customer request [16] [17]. All services offered to customers are managed by the application layer of the model. Scheduling and mapping of customer's QoS request to infrastructure level parameters and hence, allocation of resource VM are done by platform layer. Finally, the actual initiation and release of VMs are controlled by the infrastructure layer.

A. Actors in the Model

The actors engaged in our model along with their aims are stated below:

- *Customer:* The one who actually requests for resource access to the cloud service provider and consumes them. As soon as a customer agrees to the pre-defined conditions of SLA like response time etc., an application request is sent to the application layer of a service provider with QoS requirements like type of request, product type along with contract length, deadline of the contract etc. If a customer requests the upgrade of service(s) in mid-way the contract, a service provider has to manage this request intelligently matching the SLA requirements. SLA acts as a legal contract between user and service provider and if any party violates the terms of SLA, it has to pay a penalty as per the norms defined in SLA. SLA includes QoS parameters specified by customers and pre-defined parameters of service providers.
- *Cloud Service Provider (CSP):* CSP provides services to cloud customer like storage, network etc. They actually managed their own resources. CSPs purpose is to boost profit and expand their market share by undertaking as many requests as possible.
- *Cloud Broker:* A cloud broker act as an intermediary between user and provider. The role of a broker is simply to save user time and efforts by searching required services from different vendors and also it provides information about how to use cloud computing in business to support business goals. The actual budget of serving broker is contingent with the budget of the customer and anticipated discount percentage. Broker's profit is dependent on the provider price and the budget of the customer. To maximize the profit from the margin of negotiated price between customer and service provider is the main objective of the broker.

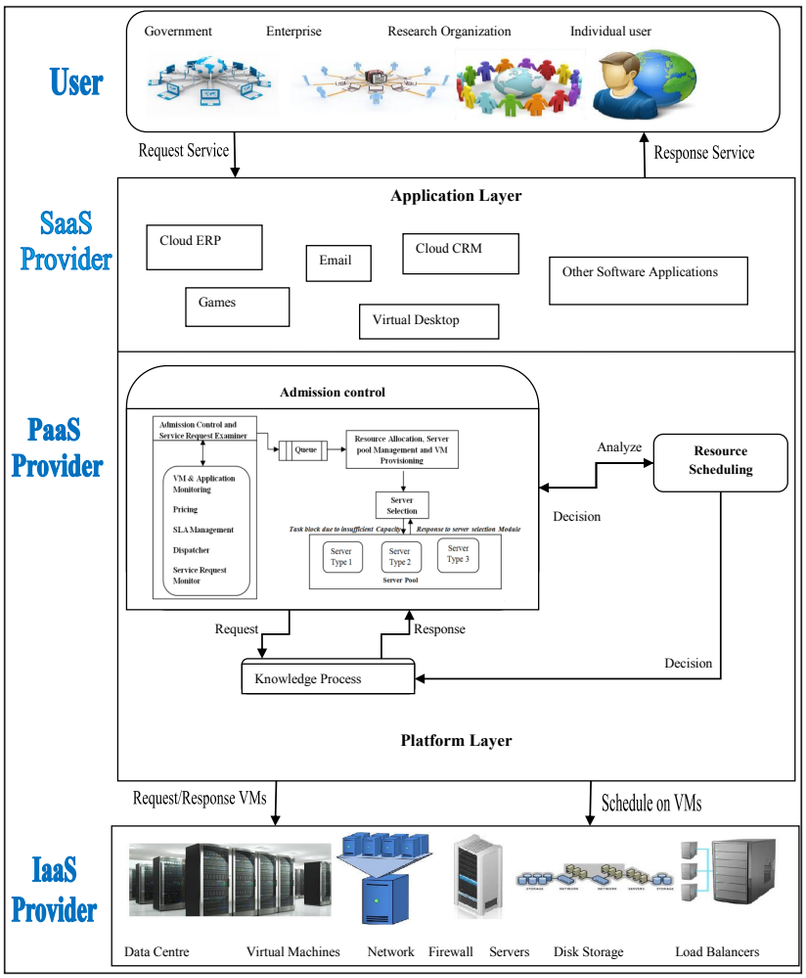


Fig. 1: Knowledge-based System Model for Admission Control and Task Scheduling in Cloud

B. Users in the Model

There are four type users in the proposed model namely: individual user, government organization, private enterprise and research organization. The request for resource allocation is initiated by the user via the application layer of the model. This request is then checked for SLA parameters and if the customer request meets provider defined SLA parameters then next checking for resource availability is done. If a resource is available, request is accepted and scheduled by a platform layer of the model. Finally, initiation of VM is done by the infrastructure layer on the basis of scheduling done and at the end of the contract infrastructure layer releases the VM thus, allocated. If at any point of contract, the customer feels a need to upgrade the contract; the whole process of request initiation is repeated. However, if constraints are met and resource is available, re-scheduling is done and a new contract is formed. Otherwise, a request is cancelled and the old contract continues. Platform layer plays a vital role in this model as major decision-making is done in it.

C. Software Services Available with the Provider

The software services available with the provider include applications that can be accessed by them from different locations and user devices. This service is provided via a thin user interface, which can either be a program interface or a web-based interface. The end-user here is not required to manage the infrastructural components like servers, operating systems, network, etc. of a cloud. Only configuration settings are customized as per user requirements. This generates the need for application software managed and initiated by the browser to meet the user demand. Software as a service plays a significant role in any enterprise model. It is helpful in managing organizations human resources, business processes and their workflow, enterprise resource program (ERP), consumer relationship management (CRM) and other integrated applications. For clients or users, it is beneficial since they are not required to make any investment in servers or buying licensed software.

D. Components of the Admission Control Mechanism

- *Service Request Examiner and Admission Control:* Before accepting or rejecting any new user request, server request examiner and admission control mechanism performs its evaluation so as to get the clarity of the QoS requirement. This helps in the minimization of SLA by keeping a check on the resource overloading as the number of available resources is limited. For making the resource allocation decisions effective and efficient, continuous monitoring of the cloud system is required. This will provide regular updates about the availability of virtualized resources using VM monitoring mechanism and average workload processing status using service request monitor mechanism. The key that ensures the successful serving of a large number of task requests from the end-user meeting the SLA norms is known as the automatic resource management technique. It also helps in the dynamic allocation of resources, so that all accepted resources can be served efficiently.
- *VM and Application Monitor:* On the basis of accepted services, the resource management system in a CCE keeps the track of the status and the performance of the available resources at different levels. Here VM monitor mechanism is used for the evaluation and monitoring of the capacity of VM that available for a new request allocation, whereas application monitoring mechanism is used for the keeping the track whether all the terms of SLA are being followed or not. If any breach in SLA is identified, then a notification is sent to SLA resource allocator which further takes the most suited action for preventing this violation.
- *Pricing Model:* Services in the cloud whether hardware or software are charged on the basis of the pay-per-use model. The greater the resources consumed the higher is the cost. This generates a necessity for the deployment of a pricing strategy that can help the provider to attain the objective of profit maximization and meeting QoS constraints as per the user demand.
- *SLA Management:* The component that keeps the record of SLA formed between users and service provider with the detailed history of their fulfilment is known as SLA management. This record helps accounting system to compute the final cost of the allocated resources by identifying their level of actual usage by the requested service. This cost is finally charged from the end-user. The information stored in SLA management records also proves to be useful for the service request examiner and admission controller for improving the quality of resource allocation decisions.
- *Dispatcher:* For the deployment of an application on the suitable virtual resource a dispatcher is used. It also performs the responsibility of creating an image of the VM and their initiation on a selective host.
- *Service Request Monitor:* The monitoring mechanism that evaluates the progress of the executed service request is known as a service request monitor.
- *Scheduler:* Scheduling of task on the available VMs is done by the scheduler. It queues the tasks after determining their priority and decides as to which VM is to be provisioned for it. For performing this task of scheduling, the scheduler requires the information about the current status of the datacenter e.g. the number of CPUs and amount of memory available for allocation, network bandwidth, etc. The load balancer provides the required information about datacenters to the scheduler. As soon as the task is accomplished, the pricing module is initiated for computing the final cost of resources used by the customer and the bill is sent to the user via SLA management.

E. Resources Available with the Provider

- *Virtual Machines (VMs):* For every accepted request dynamic allocation of multiple VMs could be started which provides flexibility for the configuration of different parts of resources on the physical host to meet the customized user requests. In a cloud system, every VM is fully isolated from another one in the same physical host.
- *Physical Machines:* The datacenters in a CCE consists of various servers for data computation which makes the required resources available for meeting the customer's service demand.
- *Datacenters:* In the present dynamic business world datacenters acts as the backbone for the IT infrastructure. There span consists of the wide range of applications varying from the distribution and production of energy, manufacturing industry, transportation, weather prediction and modelling, etc.
- *Load Balancer:* Load balancer is used to determine the actual amount of available resource (VM or PM) capacity. It identifies the over or underused resource both physical and virtual, and balances the workload among them, thus, aiding the establishment of control over resource utilization. It also helps in reducing power consumption by employing idle resources. Load balancer works together with scheduler and admission controller for balancing the workloads.
- *Load Balancing:* In a dynamic and heterogeneous cloud computing environment for controlling the unexpected changes in workload, providers are supposed to exploit the dynamic load balancing techniques. The selected technique must also put a check on the improper utilization of the cloud's resources, since the underutilization of resources may result in resource and energy wastage, whereas, overutilization increases the application's response time. Migration of VM is used as a solution to this problem.

V. Algorithm

This section illustrates an algorithm for the admission control mechanism in a Cloud environment. Here, a check is made to find whether a request is to be accepted or not. For this, the parameters to be considered include- an average of request arrival rate, the average workload of servers available for resource allocation, capacity utilization limit of servers and filtration coefficient of the request.

Algorithm for Admission Control Mechanism

1. Start
2. If (already a user)
3. login();
4. else (create an account)
5. then login();
6. loading SLA_packageinfo( );
7. put(meta info of task)
8. get request on the basis of package selected
9. for new request arrival
10. check server and VM availability
11. calculate present average request arrival rate and present average workload
12. check for the maximum limit of capacity utilization
13. if(for the present request average workload is greater than maximum capacity)
14. reject the request
15. else
16. calculate request filtration coefficient using formula 1- (Average workload-Maximum limit of capacity utilization)
17. then reject the request with the probability of 1- calculated request filtration coefficient
18. else accept the request
19. End

Whenever a new request arrives, admission control mechanism checks for the QoS requirement of the request. If it is found that resources could be allocated to the present request without violating any of the SLA norms then the request is accepted else rejected. For assuring the service quality, first of all the number of available servers and VMs is checked, then their average workload (which includes the workload of present request) is calculated along with the average rate of request arrival. If for the selected server and its VM, the average workload calculated is lower than its maximum capacity utilization limit then only request is accepted. This helps in the scheduling of tasks as per the resources available and hence, aids in reducing the number of SLA violations.

VI. Experimentation Implementation

In this work, CloudSim [18] version 3.0.3 has been used as a simulator for a cloud computing environment. An algorithm developed was tested in this simulated environment from both users' and providers' perspective. Windows provide the platform and other software used are:

- Net Beans 8.0.2
- JDK 1.8.0_40
- MySQL Server 5.1
- SQLyog Server ultimate v9.0.2.0
- JRE 1.8.0_40

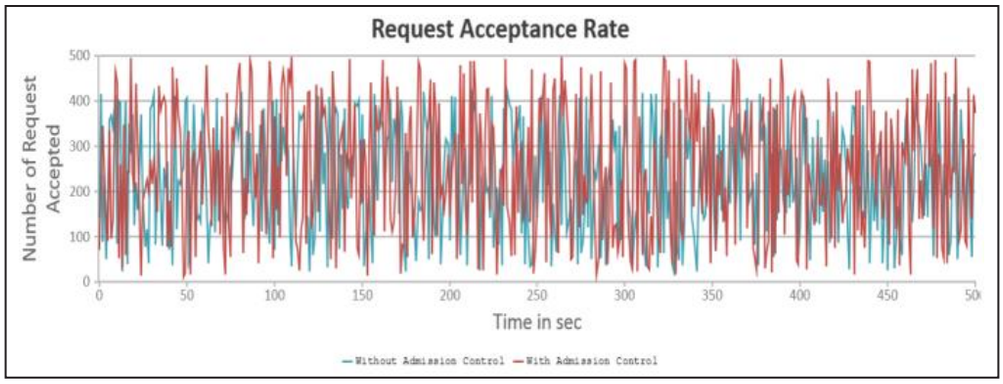
Resources used for Experimental Setup:

Our system offers four types of packages to the customers: basic, silver, gold and diamond. From these four packages, three are constant and only one package titled diamond can be customized. The configuration of the resources is as: basic pack: - 2 GB RAM, CPU core processor and Windows as the operating system, silver pack: - 4 GB RAM, CPU core processor and Windows as OS, gold: - 8 GB RAM, CPU intel core processor

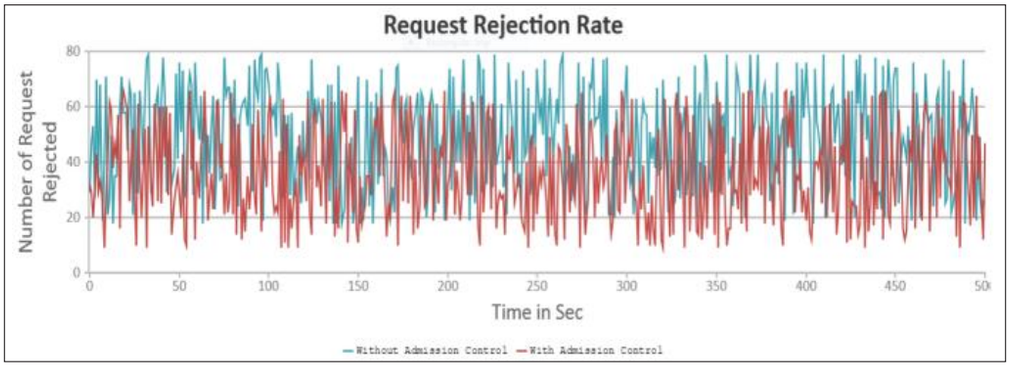
and windows as OS and for diamond configuration is tailored on the basis of a request of the user (in diamond pack local storage space is variable but the processor and RAM are constant).

VII. Analysis of Result

We have used CloudSim as a simulator of a cloud environment and have implemented the proposed model in this environment. Perspectives of both users' and SaaS providers were observed. Performance parameters of users' side are: number of requests accepted per unit of time and the speed of request processing i.e. an average of service initiation time and that of providers side are: number of VM's initiated an average profit earned. The proposed algorithm was tested on a simulator with the help of a synthetic workload. Data were synthesized randomly with the help of a suitable statistical distribution. The following graph shows the results of the model.

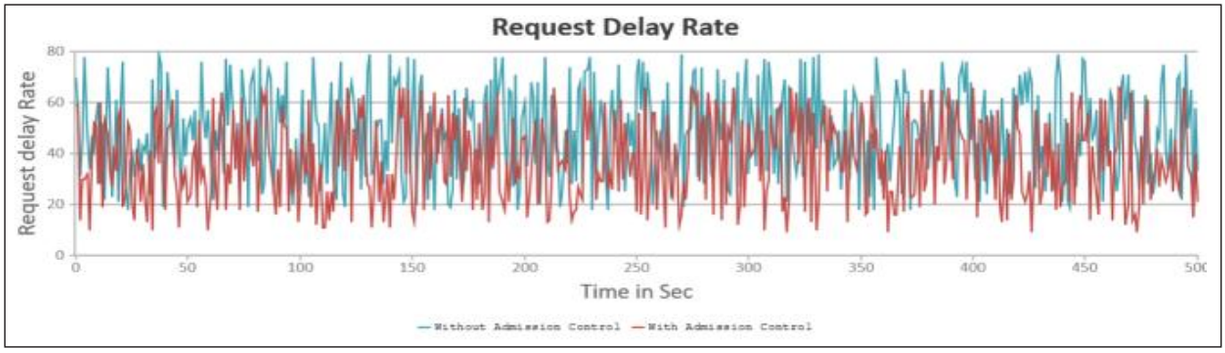


Graph 1: Variation in Number of Request Accepted



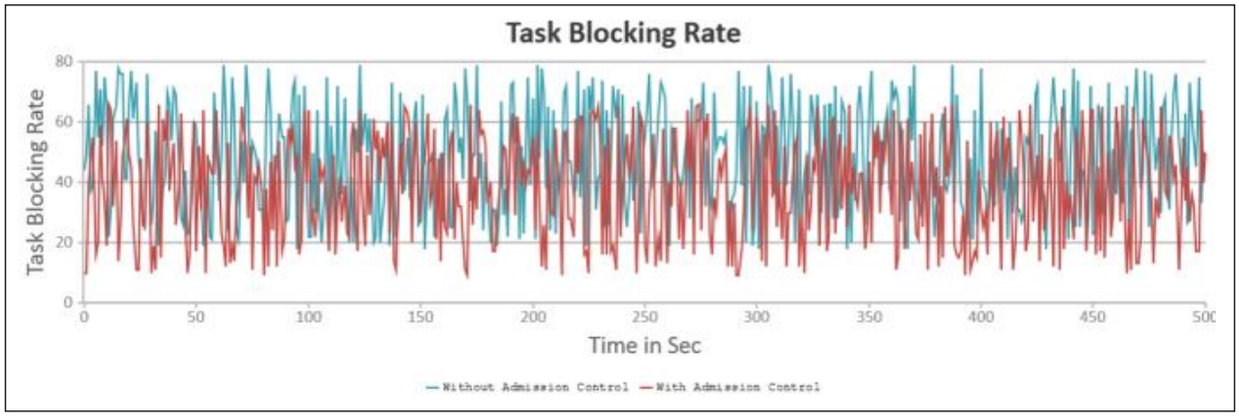
Graph 2: Variation in Number of Requests Rejected

Graph 1 and 2, shows the impact of the admission control mechanism on request acceptance and rejection rate. With the introduction of the admission control mechanism in resource allocation, the number of request accepted gets increased that ultimately results in a lower request rejection rate.



Graph 3: Average Delay Time

Graph 3, shows the impact of the admission control mechanism on request delay rate. Since every request is checked by the admission control mechanism for QoS requirements before being accepted for resource allocation, the chances of request accomplishment getting delayed get decreased.



Graph 4: Average Task Blocking Rate

Graph 4, shows the impact of the admission control mechanism on task blocking rate. Filtration coefficient is calculated to check probability with which the task is to be rejected. A task with higher probability gets rejected first. With the introduction of the admission control mechanism the blocking rate of tasks/ requests also gets reduced.

VIII. Contribution of the Research

Every new research enriches the contents of the related subject. With the help of literature review, it was found that while scheduling task in cloud one should not only consider the total completion time of all task, but must also look for some other important aspects like cost of the resources, rate of energy consumption, workload and network bandwidth, system capacity, task response time, the threshold for capacity utilization, etc. This paper presents an algorithm which considered both capacity utilization and systems average workload along with SLA constraints and resource availability to determine whether a task should be accepted or rejected. This will help in pre-filtering of task and would minimize the violation of SLA, since, if not checked properly a newly admitted task can violate the functioning of already executing a task which would ultimately increase the number of SLA violations and incur penalty cost. The model is helpful in reducing SLA violations and enhancing providers' profit.

IX. Conclusion, Limitation and Future Work

The present paper is an attempt to devise a model and algorithm for admission control mechanism so as to manage the acceptance of requests/tasks assigned by cloud users in such a way that the QoS requirement of users are met and no SLA term gets violated. Thus, the work helps in reducing the number of SLA violation and their consequences. Proposed algorithm focuses towards the admission of a task in the cloud system and in future, we would try and extend our work to devise some strategies for resource scheduling after the request has been accepted by our admission control mechanism. These strategies will focus on reducing the delay in task accomplishment and hence, the reduction in penalty cost. Work will also focus on enhancing the customer satisfaction level, controlling the cost and thereby increasing the overall revenue of the system. Different users in the cloud have different demands of quality and resource which acts as a limitation of the study since to satisfy this heterogeneous user demands with limited available resources is not an easy task.

References

[1] A. Kushwaha, P. Pathak, and S. Gupta, "Review of optimize load balancing algorithms in cloud," *International Journal of Distributed and Cloud Computing*, vol. 4, no. 2, pp. 1-9, 2016.

[2] A. Pandey, "Cloud computing implementation: An analysis using systems approach," *International Journal of Distributed and Cloud Computing*, vol. 4, no. 2, pp. 10-22, 2016.

[3] N. Ahuja, P. Kanungo, and S. Katiyal, "SLA based rescheduling of task for optimum allocation of resources in cloud computing environment," *SRIMCA*, ISSN: 0974-3308, vol. 12, no. 1, pp. 65-78, June 2019.

[4] H. N. Hoang, S. L. Van, H. N. Maue, and C. P. N. Bien, "Admission control and scheduling algorithms based on ACO and PSO heuristic for optimizing cost in cloud computing," *Research Developments in Intelligent Information and Database Systems,* pp. 15-28, Springer, 2016.

[5] M. R. Ghori, and A. A. Ahmed, "Review of access control mechanisms in cloud computing," Int. PostGraduate Conf. Appl. Sci. & Phys. 2017, Dec. 7, 2017, Johor, Malaysia. *J. Phys.: Conf. Ser.*, vol. 1049, 01209, 2018.

[6] N. Ahuja, P. Kanungo, S. Katiyal, and P. Parandkar, "Optimum management of resources in cloud computing environment: A challenge," 2015 *Int. Conf. "Comput.*

for Sustain. Global Develop." INDIACom, Organised by BVICAM, New Delhi, Mar. 2015, pp. 4.30-4.33.

[7] J. Varghese, and S. Jagannatha, "Task scheduling and VM allocation in cloud computing: A survey," *International Journal of Distributed and Cloud Computing*, vol. 7, no. 2, pp. 7-18, 2019.

[8] R. Buyya, S. K. Garg, and R. N. Calheiros, "SLA-oriented resource provisioning for cloud computing: Challenges, architecture, and solutions," *Int. Conf. Cloud and Service Comput.,* IEEE Computer Society Washington, DC, USA, ISBN: 978-1-4577-1635-5, 2011, pp. 1-10.

[9] H. Goudarzi, and M. Pedram, "Maximizing profit in cloud computing system via resource allocation," In *ICDCSW'11: 31st Int. Conf. Distrib. Comput. Syst. Workshops,* Minneapolis, IEEE, 2011, pp. 1-6.

[10] F. Motavaselalhagh, F. S. Esfahani, and H. R. Arabnia, "Knowledge-based adaptable scheduler for SaaS providers in cloud computing," *Human-Centric Computing and Information Science*, vol. 5, no. 16, pp 1-19, Springer, 2015.

[11] M. S. Lakshmi, S. P. Kumar, M. Janardhan, and K. Gayathri, "Machine learning methods for refining SLA based admission control and resource allocation in cloud computing," *International Journal of Advanced Research in Computer Science*, vol. 8, no. 9, pp. 834-840, 2017.

[12] M. A. Khoshkholghi, M. N. Derahman, A. Abdullah, S. Subramaniam, and M. Othman, "Energy-efficient algorithms for dynamic virtual machine consolidation in cloud data centers," *IEEE Access*, vol. 5, pp. 10709-10722, 2017.

[13] Y. He, J. Huang, Q. Duan, Z. Xiong, J. Lv, and Y. Liu, "A novel admission control model in cloud computing," *Networking and Internet Architecture*, pp. 1-14, 2014. [Online]. Available: arXiv:1401.4716 [cs.NI]

[14] Y. Choi, and Y. Lim, "Optimization approach for resource allocation on cloud computing for IoT," *International Journal of Distributed Sensor Networks*, vol. 2016, Article ID 3479247, pp. 1-6, Hindawi Publishing Corporation, 2016. [Online]. Available: http://dx.doi.org/10.1155/2016/3479247

[15] Z. Zhou, and H. Zhigang, "Task scheduling algorithm based on greedy strategy in cloud computing," *The Open Cybernetics and Systemics Journal*, vol. 8, pp. 111-114, 2014.

[16] L. Wu, S. K. Garg, and R. Buyya, "SLA-based admission control for a software-as-a-service provider in cloud computing environments," *Journal of Computer and System Sciences*, pp. 1280-1299, Elsevier, 2012.

[17] L. Wu, S. K. Garg, and R. Buyya, "SLA-based resource allocation for software as a service provider (SaaS) in cloud computing environments," *11th IEEE/ACM Int. Symp. Cluster, Cloud and Grid Comput. (CCGrid),* Newport Beach, CA, ISBN: 978-1-4577-0129-0, 2011, pp. 195-204.

[18] R. N. Calheiros, et al., "CloudSim: A toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms," *Journal on Software-Practice and Experience*, vol. 41, no. 1, pp. 23-50, John Wiley & Sons, Inc. New York, NY, USA, 2011.