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A Survey on Load Balancing Algorithms in Cloud Computing

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***Abstract*—** Cloud computing mainly does not focus on local resource instead; it uses shared computing resources applications or resources. It has emerged as a new type of computing for accessing present network, managing computer resources and managing distributed computing across the network in order to achieve high degree of precision and reliability various challenges needs to be addressed. One of the challenges in cloud computing is load balancing. Load balancing is important due to the fact that it allows achieving balance in the load by distributing it across the system to all its nodes. Cloud environment allows various ways to achieve load balancing. This includes managing the load on CPU, network load and the load capacity of storage. The greatest impact of balancing the load in cloud computing environment is that it has higher satisfaction of the users as well as it utilizes the resources efficiently. Proper load balancing support substantial improvement of the system, building a fault tolerant system by creating backup and increase flexibility of the system so that it adapts the modification. In cloud computing, there are various algorithms to achieve load balancing and these algorithms behave differently with its some advantages and disadvantages. In this paper we present a study on the different load balancing algorithms in cloud computing environment and analyze the results based on make span metrics. The results of the experiments depict the efficiency of Round Robin, Shortest Job First, Ant Colony Optimization and Honey Bee load balancing algorithm in terms of make span and we find that Honey Bee load balancing algorithm give the best results among the other load balancing algorithms.

***Keywords*—**Cloud computing; Load balancing; Static Load balancing; Dynamic Load balancing; Algorithms; Load balancer; Load balancing metrics.

I. INTRODUCTION

Cloud computing is an emerging method for large-scale distributed computing. Cloud computing has moved data and computing to large data centres form mobile and local personal computers [13]. Cloud computing is a need for high performance computing such as scientific and engineering application modelling, simulation and analysis of complex systems like climate, galaxies etc. [14]. It can be termed as an on-demand network access to a shared pool of computing resources [15][30]. Cloud computing is capable of harnessing the power of Local as well as Wide Area Network (WAN) to use resources remotely, resulting a solution that has efficiency in cost for most of real-life requirement. [16]. These resources are allowed to be quickly provisioned and de-provisioned with the help of minimal management effort or service provider interaction thus achieving availability [15][17]. This results in an exponential growth of adapting cloud computing by industries also expanding the data centre. As a result, there is a dynamic increase in energy consumption that hampers the environment in terms of carbon foot prints [15]. The link between energy consumption associated carbon emission has given rise to an energy management issue that is to boost energy efficiency [18] in cloud computing to realize green computing [15][19]. Apart from this there are also existing issues like load balancing, server consolidation and virtual machine migration that are not addressed [15][18][20].

A. CLOUD SERVICES

Fig1.1 shows the layered architecture of cloud services. Cloud services are basically divided into six types namely Infrastructure as a Service (IaaS), Network as a Service (NaaS), Platform as a Service (PaaS), Identify and policy Management as a Service (IPMaaS), Data as a Service (DaaS) and Software as a Service (SaaS). These services fill into Hardware Level, System Level and Application Level. The Hardware Level provides storage, CPU cycle and Network services. The System Level provides platform to run end user's application. The Application Level provides specific applications for dedicated end-users.

***Infrastructure as a Service (IaaS)*:** In IaaS, the consumers are allowed to deploy and use arbitrary software such as operating systems remotely. In this type of service, the consumer only has access and control over the storage and deployed application. Management of the underlying cloud infrastructure is not a concern for the consumer.

***Platform as a Service (PaaS*):** In this type of service the consumers are allowed to create to software using tools or libraries from the cloud provider. The consumer also has control over the software deployment and configuring settings. The cloud provider provides the network servers storage and other services.

Software as a Service (SaaS): This service allows software to be hosted centrally and accessed via a thin client e.g. a browser.

This service forms the layered architecture of Cloud Computing. It is basically the design of software applications that users on-demand services through internet. Cloud Architecture are based on infrastructure that is used only when its needed that draws the necessary resources on-demand and performs the specific job and then sets it free. This service can be accessed from anywhere though thin client such as web browser etc.

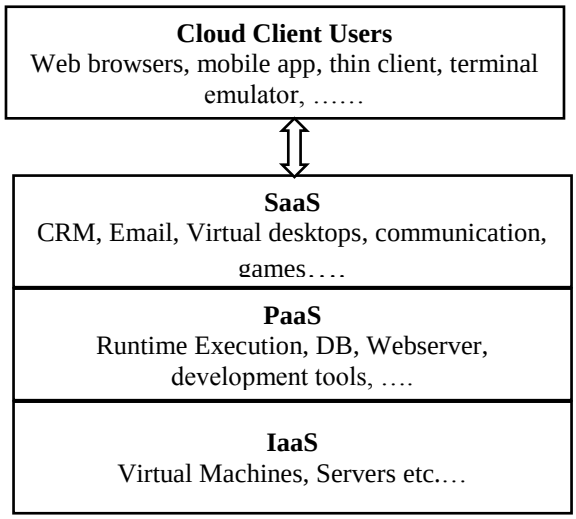

Figure 1. Layered Architecture of Cloud

This service forms the layered architecture of Cloud Computing. It is basically the design of software applications that users on-demand services through internet. Cloud Architecture are based on infrastructure that is used only when its needed that draws the necessary resources on-demand and performs the specific job and then sets it free. This service can be accessed from anywhere though thin client such as web browser etc.

B. TYPES OF CLOUD

Basically, clouds are of the following types:

(a) Private Cloud: In private cloud, data and processes are serviced within the corporate firewall of an organization. The management of the cloud is wholly dependent on local manpower. A Cloud Provider is not used.

(b) Public Cloud: In public cloud, a Cloud Service Provider manages and makes resources available to one over the internet via web applications. The resources are dynamically provisioned and de-provisioned. Resources are basically shared between users.

(c) Hybrid Cloud: Amalgamation of private and public clouds is termed as hybrid cloud. This type of cloud consists of multiple internal or external providers.

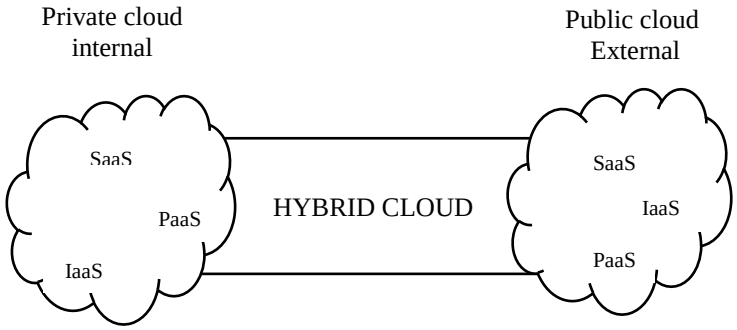

Figure 2: Public, Private and Hybrid Cloud

C. VIRTUALIZATION

Cloud computing is vastly supported by virtualization. Virtualization is separating the underline hardware from the operating system. As a result, the entire operating system along with application can be transferred from one physical machine to another. Virtualization helps in scalability. Virtualization is of two types: **(a)** Client installed **(b)** Hypervisor. In client installed virtualization software an operating system is installed on a piece of hardware and on top of its client virtualization software is installed. Using the client virtualization software, instances of different operating systems can be created and migrated as when needed. In case of hypervisors are types of operating system which are installed on to hardware. E.g. ESxi.Basically, virtualization refers to abstraction of logical resources away from the underlying hardware resources to increase flexibility, reduce costs etc. Under Virtualization computing environments can be created, expanded, shrunken or moved dynamically.

D. SCALABILITY

One of the most important feature of cloud computing is Dynamic Scalability. Dynamic resizing can be termed as a feature that allows server to resize the virtual machine as per requirement of resources. Equally distributing the load amongst the nodes is an important aspect that is too considered for efficient working of the nodes. Cloud scalability mainly is of two types:

a. **Horizontal Scalability**: It is basically connecting multiple resources/servers to work as an individual

computing unit. Same computing units are connected together to scale out the computation.

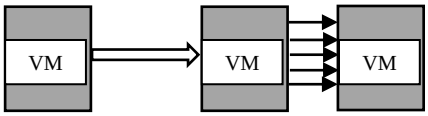

Figure 3. Horizontal Scaling of VM

b. **Vertical Scalability**: The existing hardware or software is increased in order to meet the requirement. It is also known as scaling up. Auto scaling is the ability to scale up or down as per requirement dynamically. When the demand increases the system is scaled up automatically and with the decrease of demand it shrinks. The auto scaling infrastructure is shown in Fig1.3 which helps in achieving load balancing.

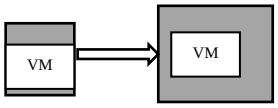

Figure 4. Vertical Scaling

c. **Auto scaling** is the ability to scale up or down as per requirement dynamically. When the demand increases the system is scaled up automatically and with the decrease of demand it shrinks. The auto scaling infrastructure is shown in **Figure 5** which helps in achieving load balancing.

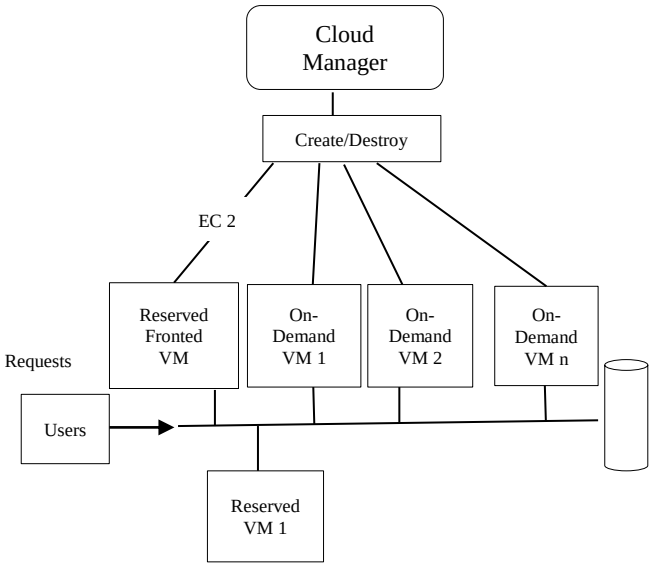

Figure 5. Auto scaling in cloud

This paper is organized as follows. Section II gives an insight to load balancing its types and the policies it incurs. Section III discusses the various existing load balancing algorithms in cloud computing environment. In section IV, some of the existing algorithms are analysed and simulated using cloudsim. Finally, the conclusion of this paper is given in section V.

II. LOAD BALANCING

Large data centre keeps up allocating and de-allocating services as per need. To achieve high degree of utilization and throughput, services need to be balanced. Load balancing is a method for distributing the work load across nodes in the cloud. Workload is the total processing time that is needed to complete all the tasks assigned. The primary goal of load balancing is to avoid situation in which one node is overloaded while others are idle. It also ensures efficient and fair distribution of computing resources. To improve efficiency and to remove overheating of Nodes Load balancing plays an important role. Load balancing is distributing workloads within different nodes available in the cloud.

Load balancing also helps in achieving green computing i.e reducing the carbon emission. Minimizing the consumption of resources using Load Balancing can result in reduced cost and helps to achieve green computing [15][21]. Scalability, one of the features of cloud computing can also be achieved through load balancing [19]. The basic factors are:

(a) **Limiting Energy Consumption:** Overheating of nodes or Virtual Machines due to excessive overload results in high amount of energy consumption. This energy consumption can be reduced using Load Balancing [22].
(b) **Reducing Carbon Emission:** with the increase in Energy consumption carbon emission also increases equally. Load Balancing helps in reducing the consumption of energy thus reducing carbon emission [22].

The main goal of Load Balancing as discussed by authors of [23][24] are

(a) Substantial improvement of performance.
(b) Stability maintenance of the system.
(c) Building a fault tolerant system by creating backup.
(d) Increase flexibility of the system so that it adapts the modification.

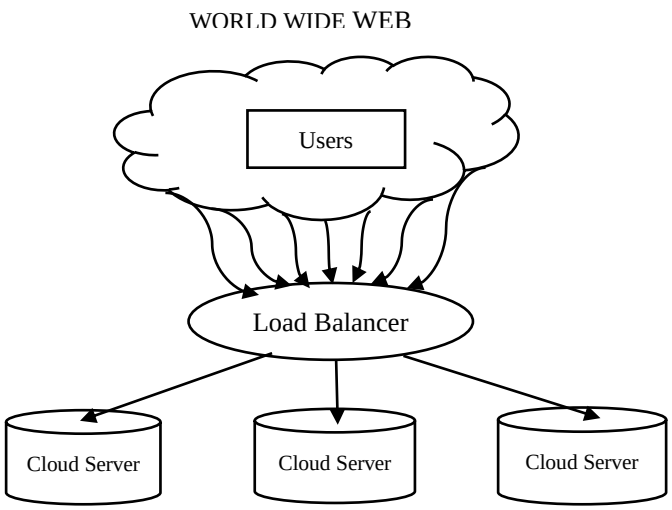

Figure 6. Working of a Load Balancer

The following subsection gives us an idea of the different types of load balancing in cloud environment and the policies used in Dynamic Load Balancing Algorithm.

A. *Classification of Load Balancing Algorithm*

The classification of load balancing Algorithm is mainly based on Process Origin and Current state of the system.

Based on process origin, Load Balancing algorithm is classified as [25][26][27]:

(a) **Sender Initiated**: In this type of load balancing algorithm, a request is initiated by the client and waits until availability of a receiver for accepting the workload
(b) **Receiver Initiated**: In this type a sender ready to share the workload has to wait until a receiver initiates a acknowledged request.
(c) **Symmetric**: It is an amalgamation of both senders initiated and receiver initiated.

There are two types of Load Balancing Algorithm based on the present state of a system

a. ***Static Algorithm:*** Static Algorithms are best suited for environments that contains resources of same type and where changes are less acceptable [12].

b. **Dynamic Algorithm**: Dynamic Algorithms are suitable for heterogeneous environment [12].

B. *Static Load Balancing Algorithm*

This type of load balancing algorithm requires previous knowledge about the resources and applications of the system. The present state of the system is independent of balancing load. These types of load balancing algorithm, allocates a task/jobs to a processor or fix node [28]. In this type of load balancing the work load is distributed to nodes with respect to the evaluated performance of the processors. Since this type of algorithm is non-pre-emptive in nature, task allocated to a virtual machine is always executed at the same [28].

The main disadvantage of Static Load Balancing is that a processor is assigned a task only after the process is created. A task allocated to a particular virtual machine remains the same until it completes its execution. It does not allow changes for choosing virtual machine irrespective of the fact that machine is over loaded or under loaded. Selection of virtual machine is fixed as an when tasks are created.

C. *Dynamic Load Balancing Algorithm*

The current state of the system plays a vital role in balancing the work load. Dynamic Load Balancing Algorithm has the capability of moving a task/job from over utilized node to an underutilized node for faster execution. In dynamic Load Balancing if any node fails the whole system does not halt. A frequent degree of communication amongst the nodes is always active that generates more messages than non-distributed in the dynamic load balancing algorithm.

D. Dynamic Load Balancing Policies

A Dynamic Load Balancing Algorithm has five major policies [41] and they are as follows:

a. Transfer Policy

This policy used for selecting a task or a process from a local machine to a remote machine.

b. Selection Policy

The selection or identification process of a processor or machine that takes part in load balancing is governed by this policy.

c. Location Policy

The policy used by a node to share the task by an over loaded machine.

d. Information Policy

This policy is used for collecting all information that is needed for load balancing.

e. Load Estimation Policy

The total approximate work load of a processor or machine is decided by this policy.

III. EXISTING LOAD BALANCING ALGORITHMS IN CLOUD COMPUTING

Different load balancing algorithms are available in cloud computing environment, these algorithms are studied and compared based on the predefined metric make span, Following are the load balancing techniques that are widely used in clouds.

Round Robin Algorithm

B Sotomayor et al [1] proposed an algorithm similar to round robin algorithm of scheduling. This is a static load balancing algorithm where the tasks are distributed amongst the virtual machine evenly. Each task after being allocated to a virtual machine, the remaining tasks are then allocated to the virtual machine allocated first in cyclic manner. This process is repeated until all tasks are allocated to virtual machines. This method does not consider the allocation procedure from remote system rather it does it locally. This disadvantage of this method is that irrespective of whether a virtual machine is already loaded or not new tasks might be allocated to the already loaded virtual machine which should not be encouraged. This type of load balancing is not suitable for cloud environment where the number of tasks is dynamic.

Modified Throttled algorithm: Shridhar G. Domanal and G. Ram Mohan Reddy [2] proposed a Modified Throttled algorithm for cloud load balancing. This method is based on round robin algorithm. According to the author, this algorithm basically focuses on how jobs are allocated to available virtual machines. An index table of virtual machines and also state of virtual machines (busy/available) is maintained by this algorithm. Initially, this algorithm selects a virtual machine at first index depending upon the state of virtual machine. If the new request arrives, the virtual machine at the previous virtual machine index+1 is chosen depending on the state of virtual machine [19].

Shortest Job First Based Load Balancing Algorithm

K Suchita et al [3] proposed a static load balancing algorithm based on the shortest job first algorithm for scheduling. In this method the allocation of tasks to a particular virtual machine is done depending upon the length of the task. The task with the shortest length is allocated to the available virtual machine. This method is suitable for environment where the task length does not vary. A task with higher length may have to wait for long, waiting for completion of shortest length tasks. The disadvantage of this method is that priority is not considered for tasks.

Ant Colony Optimization (ACO):

Medhat A.Tawfeed et.al [4] in 2013 presented a dynamic cloud task scheduling based Ant Colony Optimization Approach for allocation of incoming tasks to virtual machine's efficiently to minimize the make span. The author performed simulation of the method using Cloudsim simulation tool kit. In the paper, it compares task scheduling based Ant colony optimization approach with different scheduling algorithm, and finds that Ant colony gives better result as compared to RR, FCFS scheduling algorithms. Mainly ACO algorithm [9] is proposed for load balancing of nodes and its aim is to efficiently distribution of workload among the nodes [10]. The idea is that ants will start approaching towards the food source starting from the head node when the request is initialized and it maintains a table for its route. This is basically the pheromone table. This helps the Ants to records their data which helps in making the decision in future, keeping record of every node visited. As and when ants are created the pheromone table is updated with the latest value. Each ant has a result set associated with it that is recorded to find a complete solution. This result set is continuously updated. The main aim of the ant is to find a new food source using this result set. Thus, the main aim of this algorithm is that it efficiently distributes the work load among the nodes.

ACCLB- An algorithm based on ant colony and complex network theory is proposed by Z. Zhang et al. [5]. Load balancing is achieved by using the feature from small-world and scale-free. The advantage of this method is that it is suitable for overcoming heterogeneity. This method also supports dynamic environment. This method promises fault tolerance at its best. Apart from support of fault tolerance it also is scalable. As a result, it helps in improving the overall performance of the system.

Honey Bee Behaviour inspired Load Balancing (HBB-LB): Dinesh B. L.D, P.V. Krishna [6] proposed a Honey Bee Behaviour inspired Load Balancing (HBB-LB) Technique, according to [11][13], HBB-LB helps to distribute the load evenly for the virtual machines maximizing the overall throughput of the system. This method also accepts priority of tasks to be executed in virtual machine. Overloaded and under loaded or balanced virtual machines are identified by examining the workload of virtual machine. Based on these VMs are grouped [10]. According to the load on virtual machine the task is scheduled on virtual machines, which is removed earlier. To find the least loaded virtual machine for the current task, tasks that are removed from the system from over loaded virtual machine are helpful. In the next steps forager bee is used as a Scout bee [7].

Particle Swarm Optimization (PSO): Kennedy and Eberhart [8] proposed a load balancing algorithm named as Particle Swarm Optimization (PSO). It is a Meta heuristic algorithm based on optimization technique. The PSO is a self-adaptive global search optimization technique. It is same as Genetic algorithm (GA). Bit allocation of tasks is done in this method. It is seen that at least three times cost savings is possible with PSO if compared to best resource selection (BRS) based mapping for application workflow.

IV. SIMULATION RESULTS

This section discusses the different load balancing algorithms based on simulation done in cloudsim [29]. Cloudsim is a tool for modelling and simulating cloud environment. In order to simulate we considered the number of Data Centre as 50 and the number of cloudlets in the range 100 to 1000. We compute the make span of the system. Make span is the maximum completion time for all tasks. The model was reconfigured according to the following parameters:

Table 1 shows the Virtual Machine (VM) parameters:

Parameters	Value
Data Centre OS	Linux
Memory of VM	256mb
MIPS	500
No. Of Processors	1
Size	1000

Table 1. VM parameters

In figure 7, the comparison of Round Robin and Shortest job First algorithm is shows based on the parameters as stated in Table 1.

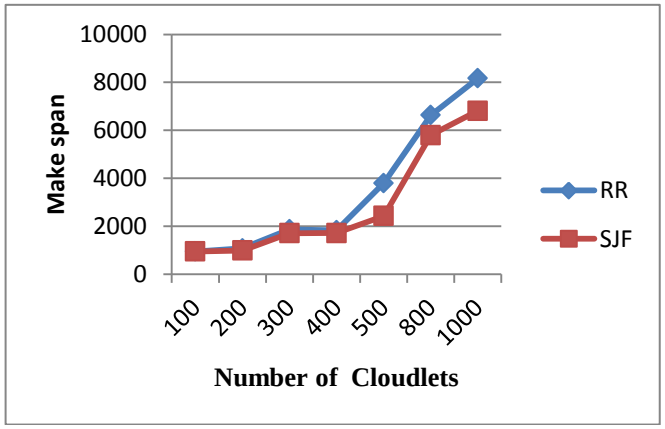

Figure 7. RR vs SJF

As it can be seen that for fewer number of cloudlets/tasks both Round Robin and Shortest Job First performs equally in terms of make span. But with the increase in the number of cloudlets SJF performs better than Round Robin. This is due to the fact that RR allocates tasks to a virtual machine in cyclic manner and does not consider whether a VM is overloaded or not. But in case of SJF the task with shortest length is allocated to a virtual machine thus reducing the overall make span.

Figure 8 shows the comparison of Ant Colony Optimization Algorithm and Honey Bee load balancing algorithm based on the parameters as stated on table 1

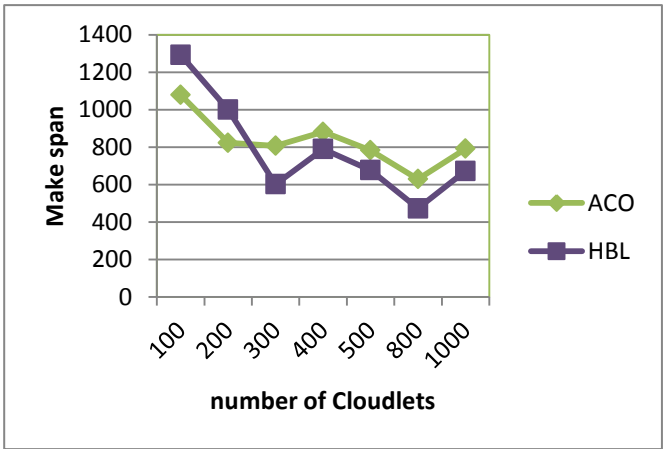

Figure 8. ACO vs HBL

As seen from the figure ACO performs better than HBL for less number of cloudlets. But as the number of cloudlets increases HBL outperforms ACO in terms of make span. This is due to the fact in case of HBL, initially tasks are allocated to virtual machine randomly. Depending on the current state of virtual machine all upcoming tasks are allocated to under loaded virtual machine thus minimizing the make span of the system.

Figure 9 cumulatively shows the comparison of all the load balancing algorithms.

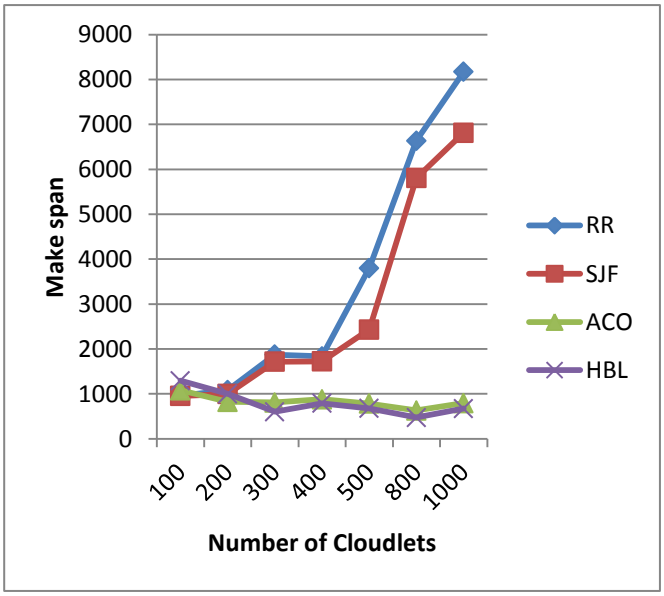

Figure 9. RR vs SJF vs ACO vs HBL

As it can be seen that HBL outperforms all load balancing algorithms in terms of make span thus improving the efficiency of the system.

V. CONCLUSION

Cloud computing allows wide range of users to access distributed, scalable, virtualized, software and hardware resources over the Internet. One of the important issues in cloud computing environment is load balancing. Load balancing improve the overall efficiency of the system. This paper discusses on cloud computing, load balancing, types of load balancing algorithms and simulation results using cloudsim. This paper deals with load balancing algorithm for cloud environment. We have simulated the results of these algorithms and compared it with various load balancing algorithms with respect to one of the load balancing metrics make span. We conclude on the basis of the results that amongst Round robin, Shortest Job First, Ant Colony Optimization and Honey Bee Load balancing algorithms for cloud environment, Honey Bee Load balancing algorithm shows significant improvement over the other algorithms. Future work is associated to designing a new dynamic load balancing algorithm for better resource utilization, fast throughput and minimum response time of the cloud computing environment.

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