

Load Balancing in Cloud Computing: A Survey on Popular Techniques and Comparative Analysis

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Abstract

Cloud Computing is universally accepted as the most intensifying field in web technologies today. With the increasing popularity of the cloud, popular website's servers are getting overloaded with high request load by users. One of the main challenges in cloud computing is Load Balancing on servers. Load balancing is the procedure of sharing the load between multiple processors in a distributed environment to minimize the turnaround time taken by the servers to cater service requests and make better utilization of the available resources. It greatly helps in scenarios where there is misbalance of workload on the servers as some machines may get heavily loaded while others remain under-loaded or idle. Load balancing methods make sure that every VM or server in the network holds workload equilibrium and load as per their capacity at any instance of time. Static and Dynamic load balancing are main techniques for balancing load on servers. This paper presents a brief discussion on different load balancing schemes and comparison between prime techniques.

Index terms— load balancing, dynamic resource allocation, cloud load balancing techniques.

1 Introduction a) Fundamentals of Load Balancing

workload is of many types in real time and can be segregated into various categories like CPU load, network load, memory capacity issue, etc. While talking about cloud systems, load balancing mechanisms are used to share the load among virtual machines accessed by user nodes (end user devices) to improve resource utilization of the servers, enhancing the quality of service and providing high satisfaction to the users. Due to load sharing, every available processor in the cloud can work efficiently and smooth operations can be performed reducing delays [1]. Load balancing refers to the distribution of incoming load or tasks equally among the cloud nodes to achieve a good QoS (Quality of Service) by reducing response time and maximize resource utilization [2]. The dynamic load balancing algorithm uses system information while distributing the load [3]. A dynamic scheme is more flexible and fault tolerant. Load balancing enables advance network facilities and resources to offer better response and performance. Several algorithms are used to balance service requests or cloud data among nodes.

Cloud providers handle entire user requests load for smooth provisioning of services. Therefore, cloud service provider (CSP) uses numerous techniques for balancing the load. Load balancing is usually applied on a large amount of data traffic and servers to distribute work. Advanced architectures in the cloud are adopted to achieve speed and efficiency. There are several characteristics of load balancing such as equal division of work across available processors, facilitation in achieving the satisfaction of clients, improvement in end-to-end efficiency of the architecture, faster response time, and appropriate service allocations to achieve complete resource utilization [4]. There are two types of load balancing on the whole, i.e., Static and dynamic load balancing. Dynamic load balancing is used to rebalance the system being in running state when any overloaded VMs are detected. While static load balancing is used to balance the system at the starting phase by scheduling jobs to VMs. Static load balancing is generally chosen for the work as it avoids VM migration costs and delivers better quality of service (QoS) and lowers execution time [5]. Load balancing is considered as one of the most critical aspects to enhance the overall operational efficiency and performance of the cloud computing-based service provider. Balancing the oncoming load of the virtual machines equally among available resources implies that any of the running VMs

doesn't stay idle or even partially loaded while other machines are facing heavy load. On the contrary, one of the critical challenges of cloud computing is to share and distribute the given workload dynamically among the available resources. The advantages of allocating the workload to available machines incorporate the expanded use of available resources which helps in improving the general performance, through which, greater customer fulfillment can be achieved. In this paper, we provide a comprehensive overview of interactive load balancing algorithms in cloud computing. Each algorithm addresses different problems from different aspects and offers diverse solutions. Some limitations of existing algorithms are performance issue, elevated processing A time, starvation and limited to the environment where load variations are few, etc. The characteristic of an efficient load balancing algorithm dictates that it should be able to avoid overloading of any particular node. The main objective of load balancing is to assess the overall performance of the cloud computing systems in conjunction with the load balancing algorithms [6].

2 b) Objectives of Load Balancing Schemes [7-8]

? To provide a noticeable improvement in the performance. ? To include a backup plan to overcome partial or complete system failure. ? To sustain a stable system environment.
? To be able to adapt for future modifications and scalability in the system.

3 c) Benefits of load balancing [9]

? Increased Scalability: If you have a website, you must be uploading engaging content to attract readers. And it must be exciting to see a growing number of visitors on your site. However, it is significant to recall that the total volume of traffic on the website has a direct impact on the general performance of the website. If there is a sudden spike in the traffic, it might become difficult for your server to handle the excess traffic and the website may crash. Load balancing can help in spreading the traffic across multiple servers, and the increase in the traffic can be handled in a much easier manner. Depending on how the site's traffic fluctuates, the server administrators can scale the web servers up or down depending on your site's needs.

? Redundancy: The probability of hardware failure can be reduced, and the overall uptime of the website can be improved if load balancing mechanisms are used for maintaining a website or web application on more than one web server. By implementing load balancing you can achieve redundancy. This means that when the oncoming traffic to a website is distributed to more than two web servers, and if one of the servers goes offline, then the load balancer will spontaneously divert the traffic to the other online servers. When you maintain multiple load balanced servers, you can be assured that at least one server will constantly be online to control and respond to the site traffic even when there is hardware fail. This way you can reduce the downtime, maintain the uptime and improve the performance.

? Efficiently Manages Failures: Load balancing helps in detecting failures early on and manages them efficiently, making sure that failure of any kind doesn't affect the servers or the workload. One can bypass the detected failures by re-distributing the available resources to other areas which are unaffected with the use of several data centers that are spread across a number of cloud providers. This mechanism will reduce the disruption and failures.

? Increased Flexibility: IT administrators can enjoy great flexibility in handling website traffic by using multiple load balanced servers. They can perform several maintenance tasks on the server without affecting the total uptime of the website. This operation is accomplished by diverting the entire traffic to any one server and keeping the load balancer in active or passive mode. You have the flexibility of having a staggered maintenance system, where at least one server is always available to pick up the workload while others are undergoing maintenance. This method ensures that the users of the website do not suffer from any outages at any time. Most of the static load balancing techniques are non-preemptive in nature. It implies that the load once assigned to a node, it cannot be diverted to any other node [11]. The execution time required for this method is low as it has lesser communication. One of the biggest shortcomings of this technique poses a major threat to the overall performances of the system. This happens because of the load fluctuation in the distributed system. The static load balancing algorithms can be classified into four types: central manager, round-robin algorithm, randomized algorithm and threshold algorithm [12].

? Central Manager Algorithm [14]: In this technique, a central node will be designated to choose a slave node for assigning the load. The slave with lowest load will be chosen and the job will be assigned.

The central node holds the load index for all slave nodes which are associated with it. In a situation where the load is varied, the slave nodes will transmit a message to the central node. On the downside, this algorithm leads to bottleneck because it requires larger inter-process communication. The performance of this algorithm is better for dynamic activities of various hosts.

? Round Robin Algorithm [13]: This algorithm distributes the load equally among all the nodes. The workload distribution method is termed as round robin, wherein, equal load will be assigned to the node which moves about in a circular fashion without any priority. It forms a circular structure and hence the load will come back to the first node and this process continues. The nodes will hold its load index which are unrelated to allocations from the remote node. The benefits of round robin are that, it is starvation free, simple and easy to implement. Since it doesn't need any inter-process communication, this algorithm provides better performance for special

purpose applications. On the downside, this algorithm doesn't work perfectly when the given general-purpose jobs have unequal execution time.

? Randomized Algorithm [16]: In this strategy, the selection of node is made randomly without any knowledge on the current or previous load taken by the node. It is suitable for conditions where the system has equal load on each node because it is static in nature. The performance of this algorithm is found to be better for special purpose applications. The inter-process communication is not needed as the nodes maintain their own load record. In certain circumstance, a single node can be overloaded, while other nodes are still underloaded.

? Threshold Algorithm [15]: In this technique, when a new node is created, the load will be instantly assigned to it. The selection of nodes are made locally without any transmission of remote messages. A private copy of load will be maintained by each node. The characterization of load is segregated into under-load, medium-load and overload. The Dynamic loads balancing technique will supervise the alterations on the workload of the system, and it will automatically reorganize the workload appropriately. The process is carried out in three methods, i.e., transfer strategy, location strategy, and information strategy. Qualifying tasks for load transfer will be decided by the Transfer strategy, which selects the tasks that can be processed by other nodes. The remote node which should process the transferred task will be selected using Location strategy. Information strategy dictates the transfer strategies and location of nodes, and hence, it acts as an information center for load balancing algorithm.

4 b) Dynamic Load Balancing

The dynamic algorithms are designated to operate in three different controlling forms, which are termed as, distributed, semi-distributed and centralized. In distributed form, the responsibility will be segregated equally among all nodes. In a semi-distributed scenario, the network will be sub-divided into smaller clusters, in which each cluster will be centralized. In centralized load distribution scheme, a single node will be nominated as a central node of the network which will be responsible for carrying out the task of load distribution. With the cooperation of central nodes present in the clusters, the load balancing of system can be established.

? Centralized Strategy [18]: In a centralized Strategy, the load balancer will be positioned on one principal workstation node. Some of the basic characteristics of centralized strategy is:

? The list of tasks to be performed will be maintained by a master node. ? The tasks will be forwarded to the executing node ? Once the process completes a task, a request is made to the master node for another task. ? Ant Colony Algorithm [20]: The ant colony algorithm maintains the documentation and record of every node that it visits. This information is helpful for efficient decision-making efforts in the future. To select a next node, an ant will deposit pheromones during their movement. Various factors can affect the intensity of pheromones, such as distance of food, type of food, quality of food etc. The pheromones are updated as soon as the job completes successfully. An individual result set will be generated by each ant, which are then combined to construct a complete solution. Instead of updating their own result set, the ant will constantly update a single result set. Later, the solution set is updated by the ant pheromones trials.

? Throttled Algorithm [21][22]: Throttle Algorithm takes its inspiration from virtual machines. In this approach, the client or user makes a request to the load balancer to determine a virtual machine which is capable of handling the load easily and processes the operations and task laid out by the user. A table of virtual machines and their states (available or busy), will be maintained by the load balancer. Hence, the client will request to the load balancer to select an appropriate Virtual Machine to execute the obliged operations.

? Honey Bee [23]: This algorithm has got inspiration from the behavior of honey bees. This load balancing algorithm is dynamic in nature. When it comes to honey bees, they can be categorized into two types, the finders and the reapers. The finders are responsible for searching the source of honey. When a source for honey is found, the finders perform a waggle dance which can tell about the quantity and quality of the honey. Later, the reapers will travel and collect the honey from these sources. They in turn perform waggle dance to signal the amount of honey left in the source.

? Active Clustering Load Balancing Algorithm [24]: This algorithm works by segregating and grouping similar nodes together. The further operation is based on these grouped nodes. The advantage of this grouping of nodes is that, it helps the resources to boost the throughput costeffectively. A term match-maker is coined in this algorithm. It all begins when a node chooses the neighboring node, which in turn selects and matches the initial node with its neighboring node, which has similar characteristics. After successful connection, the match-maker node will be discarded. This process is repeated until the load is balanced equally. The throughput is considerably increased with this algorithm which improves the system performance and promises an efficient utilization of resources.

? CARTON [25]: CARTON is an amalgamation of load balancing (LB) and distributed rate limiting (DRL). Through load balancing, jobs are fairly assigned to the servers. DRL ensures the equal distribution of resources. Thus, the workload is dynamically assigned to improve the performance and spread the load equally to all the servers. This algorithm can easily be implemented as low communication required.

III.

5 Literature Survey

In 2012, Rattan Mishra [26] introduced "Ant colony optimization" (ACO) to avoid deadlock condition in cloud computing systems. The implementation carried out on two different job scheduling strategies, i.e., time shared and space shared. According to acquired experimental results it consumed less memory during processing of tasks as previously implemented resources and provided high performance.

In 2014, Stuti Dave et al. [27] presented a "Round Robin" (RR) for load balancing at the virtualized environment. In this paper, they have suggested improved Fair RR algorithm approach that provides dynamic time quantum strategy. When the request enters the ready queue, they are processed and calculated according to time quantum and burst time computation while VM's are allocated. Thus, FRR provide fairness to larger and smaller incoming requests at executing load resulting in faster load balancing in the cloud.

In 2012, O.M Elzeki et al. [28] has proposed upgraded "Max-Min" algorithm to escalate the Max-Min efficiency by synchronized parallel execution of task as resources and emphasizes on selecting task with maximum completion time. This algorithm computes and estimates the projected completion time of the presented tasks on each resource. With the help of this information, the projected execution time will be allocated to a resource that has the least completion time. As a final point, the scheduled task will be detached from the Meta-tasks and all the estimated times will be updated. This process will be reiterated until all the submitted tasks are executed.

In 2011, T. kokilavani [29] proposed "Load balance Min-min" (LBMM) algorithm, which is basically a grid scheduling algorithm. The Min-Min will be executed in the first round. In the next round, it picks out the resources which are bearing heavy load and reallocates them to the resources which have lesser load. It later detects the resources with high make span and then selects the tasks with lower execution time present on that resource. A comparison will be made between the make span produced by Min-Min and the completion time. If it is found to be lower, then the task is rescheduled, otherwise next higher completion time of task will be chosen. This process continues until all the resources and tasks are completely exploited.

Singh et al. [30] propositioned a novel load balancing algorithm which is known as the Vector Dot. The problems relating to hierarchical complexity of the datacenters were addressed with the help of this algorithm. It also handles the multi-dimensionality of resource loads across various servers and network switches. It extends the support to the storage in an agile data center which contains an integrated server with virtualized storage system.

Stanojevic et al. [31] proposed a technique called CARTON that amalgamates the usage of LB and DRL for cloud control. The LB (Load Balancing) is implemented to distribute the jobs equally among various available servers with an intention to minimize the associated costs and DRL (Distributed Rate Limiting) is deployed to ensure that the resources are distributed in a particular manner so that a fair resource allocation and utilization is established.

Y. Zhao et al. [32] have focused and tackled the problem of intra-cloud load balancing among physical hosts by using the technique of adaptive live migration of virtual machines. The idea of load balancing model is conceived and implemented to lower the migration time of virtual machines in a shared storage environment, in order to balance they applied load on the servers according to their capacity and processor, memory or IO utilization.

V. Nae et al. [33] proposed an Event Driven Load Balancing Algorithm (EDLBA) for a real-time Massively Multiplayer Online Games (MMOG). The algorithm operates by taking input in the form of capacity event and analyzes the components in the perspective of the resources and global state of the game session. Then later, it generates the output actions in the form of the game session load balancing act.

J. Hu et al. [34] presented a scheduling mechanism on load balancing of Virtual machines resources which uses the historical data and current state of the system. With the help of a genetic algorithm, the proposed technique provides the best load balancing and minimized dynamic migration.

A. Bhadani et al. [35] proposed a strategy to evenly balance the load in a distributed virtual machine or cloud computing environment, known as Central Load Balancing Policy for Virtual Machines (CLBVM).

H. Liu et al. [36] proposed a technique which can provide a large scale net data storage model in collaboration with the Storage as a Service model based on Cloud Storage system. This technique is termed as load balancing virtual storage strategy (LBVS). A three-layered architecture and load balancing technique with two load balancing modules is employed to achieve Storage virtualization, which is known to enhance the overall efficiency.

The Y. Fang et al. [37] examined load balancing and conferred a two-level task scheduling mechanism to meet the dynamic requirements of users and achieve better resource utilization. The working of the algorithm is quite simple. It maps the tasks on to the virtual machines, which are then assigned to the hosts depending on the available hardware resources. With this approach, the resource utilization is better and the response time for a task is improved, which in turn enhances the overall performance of cloud computing.

M. Randles et al. [38] inspected a nature-inspired algorithm, in particular, the decentralized honey-bee based load balancing technique for the purpose of providing self-organization. In the course of local server actions, the algorithm is able to accomplish global load balancing. The performance of the cloud system is enriched with higher system diversity. On the contrary, the increment in system size will not maximize the throughput. Hence, this type of algorithm is suitable for certain situations in which requires diverse population of service types.

Y. Lua et al. [39] presented an algorithm for dynamically scalable web services, known as Join-Idle-Queue load balancing. This technique presents a largescale load balancing schemes with distributed dispatchers. The process begins with identifying the idle processors across dispatchers and check for their availability. With this

information, assigning jobs to processors helps in minimizing the average length of queue at each processor. When the load balancing task is removed from the critical path of request, the incurred load will be significantly reduced. Furthermore, the communication overhead at request arrival is also reduced and the response time will not increase.

Baris Yuce et al. [40] introduced an algorithm known as "Honey bee inspired algorithm" which centers on refining the benchmark functions, which are later compared with other optimization techniques such as PSO, ACO and EV. This provides an evaluation of bee behavior and algorithm. The primary objective of this technique is to enhance the bee's algorithm with the help of adaptive neighborhood sizes and site abandonment (ANSSA) mechanism.

Author [14] [39] [41], presented a novel algorithm on content aware load balancing policy, which was termed as workload and client aware policy (WCAP). This proposed technique employs a parameter known as USP to postulate a unique and distinctive property of the arriving requests and computing nodes. The scheduler makes use of this USP information to determine the finest appropriate nodes for processing the request.

6 IV.

7 Comparison & Discussion

In this section we demonstrate various techniques used for load balancing and researchers proposed mechanisms. In Table 2 we compared various types of algorithms used for load balancing and illustrated their merits and demerits. In Table 3 of this section we illustrated the mechanisms proposed by various researchers and made a short comparison in terms of its efficiency.

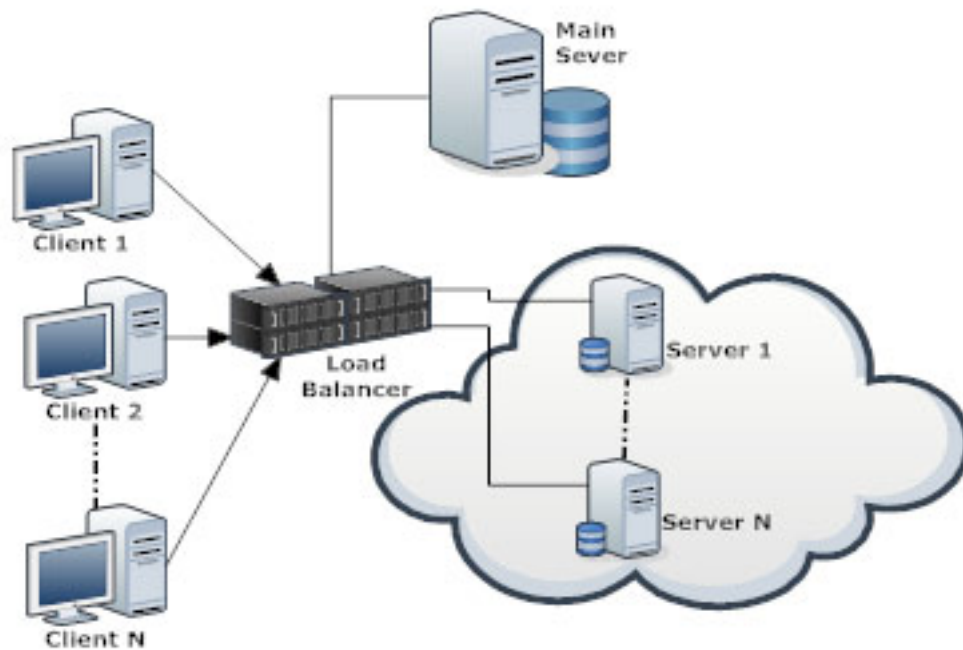
8 Throttle

Good performance as List is used to manage the tasks. Tasks need to wait for longer time.

-Static -Dynamic

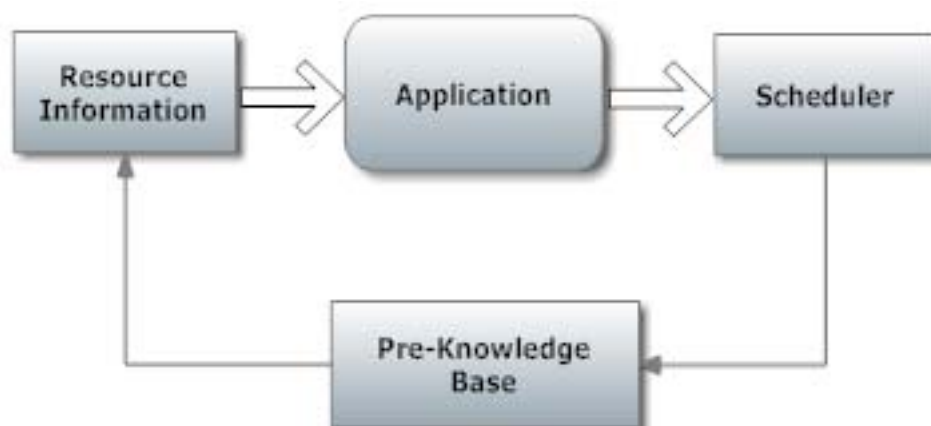
9 Conclusion

Load balancing is a procedure utilized to equally distribute the workload on available processors or VMs so that all machines share the workload and no processor is overloaded. Thus, it can be said that load balancing definitely increases throughput and reduces response time. Load balancing is done by static or dynamic load balancers that accept multiple requests from users and distributes them across servers on the cloud. Today efficient load balancing is one of the greatest concerns in cloud computing systems. To solve this issue, various techniques were proposed by researchers and experts. In this paper, we have classified types of load balancing and reviewed numerous literature about various existing load balancing methods in cloud computing environment by researchers in this field. We demonstrated the comparisons of popular mechanisms proposed by researchers in terms of efficiency and merits or demerits. Further, this survey can be extended to review various machine learning and genetic algorithm usage in load balancing arena.



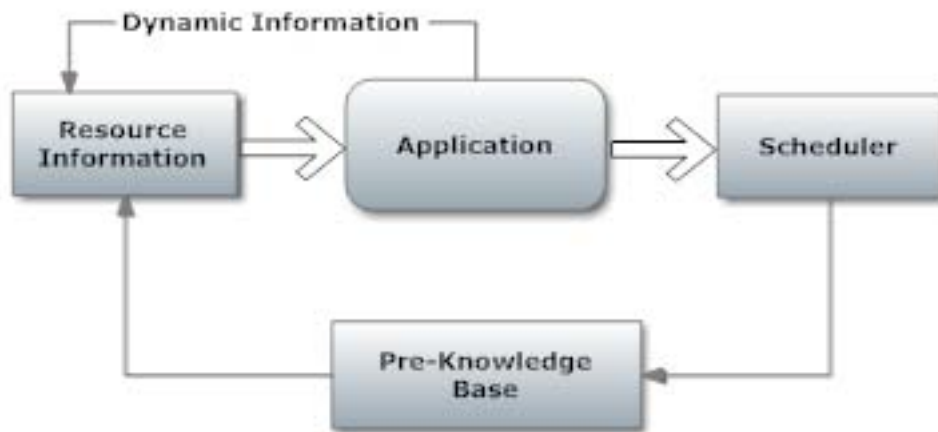
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Figure 1: Figure 1 Figure 2 :



3

Figure 2: Figure 3 :



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Figure 3: Figure 4 :Figure 5 :

1

Figure 4: Table 1 :

2

Algorithm	Static / Dynamic	Advantages	Disadvantages
Ant Colony		Information can be collected faster by the ants. ? Chooses a random VM to allot a task.	? Network is over headed so search takes longer time. ? N
Round-Robin		? This mechanism assigns the VMs, sorted in the queue with no consideration of job priority. This method is most appropriate in situations where multiple jobs to be	? The operation time of each process is not identified beforehand. ? Forecast of operation time is unfeasible.
Min-Min		accomplished within least time.	It leads to the starvation problem.
Max-Min		This method is appropriate when the jobs are with highest completion time, as it eradicates the starvation.	The job, which should be finished in the least time needs
Central Manager		Works well when dynamic operations are initiated through diverse hosts.	Sometimes leads to System bottleneck state.
Threshold		Keeps the private copy of information in node.	Can't able to distribute information, if private copy node
Randomized		Give the best performance.	At times, solitaire nodes may get burdened with tasks even as the other node is moderately laden.
Active Clustering		It balances the load pretty well.	Performs environment poorly in heterogeneous
Honey Bee		Increases throughput; Minimize response time. ? Fairness; Good performance; Equal	High priority tasks can't work without VM machine.
Carton		distribution of responses. ? Low communication is required.	It depends upon lower costs.

Figure 5: Table 2 :

3

Ref.	Name	year	Mechanism	Advantages
[27]	Stuti Dave et al.	2014	Round Robin for Cloud Virtualized Envi	
[28]	O.M Elzeki et al.	2012	Max-Min Approach	
[29]	T. kokilavani	2011	Load (LBMM)	Balance Min-Min
[30]	Singh et al	2008	Vector Dot	
[31]	Stanojevic et al	2009	Ant Colony Optimization	
[32]	Y. Zhao et al	2009	Intra-Cloud Load Balancing	
[33]	V. Nae et al	2010	EDLBA	
[34]	J. Hu et al.	2010	SOLB	
[35]	A. Bhadani et al	2010	CLBVM	
[36]	H. Liu et al	2010	LVBS	
[37]	Y. Fang et al	2010	Dual-Stage Job Scheduling	
[38]	M. Randles et al	2010	Decentralized Honey Bee	
[39]	Y. Lua et al	2012	JIQLB	
[40]	Baris Yuce	2013	Honey Algorithm	Bee Inspired
[14] [39]	Lua Y	2011	Workload And Client Aware Policy (WC	
[41]				

Figure 6: Table 3 :

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