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Performance Evaluation of Load Balancing Algorithms in Cloud Environment

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Abstract

Cloud computing has many advantages over traditional computing like scalability, elasticity, accessibility. Due to these advantages, it has gained popularity in the Information Technology industry. The popularity of cloud computing has forced all organizations (including Micro Small and Medium Enterprises) to move their businesses from traditional computing to cloud computing. This transition has increased cloud-based services worldwide. The growth in cloud adoption has resulted in a high surge of network traffic. Failure to handle this enormous traffic may result in reduced system performance, inefficient resource utilization, server outage. One of the solutions for these problems is cloud load balancers.

In this paper, we focus on a load balancing technique as first come first service (FCFS), short job first scheduling (SJF) and Round Robin for cloud load balancers to distribute load among all available resources and reduces the makespan time of tasks. The algorithm is implemented and analyzed using CloudSim simulator. Performance measurement and evaluation is done by Makespan time of number of cloudlet with given virtual machine and compare with existing algorithms.

Calculated results demonstrate that the developed method outperforms the existing method first service (FCFS), short job first scheduling (SJF) and Round Robin.

Keywords: Cloud Computing, Traditional Computing, Load Balancing Techniques, Cloudsim Simulator, Virtual Machine

Introduction

In an organization, the main challenges in information technology are the establishment and maintenance of required resources. With the dynamic variation in the numbers of users, it is difficult to predict the required resources. If the number of users is more than predicted, it results in performance degradation. If the number of users is less than predicted, it results in wastage of a large number of resources. Other than this, a company requires large manpower for the installation of required software and maintenance of resources. Establishment and maintenance of resources is an expensive and tedious task. Cloud computing provides a solution to all these problems. Cloud computing provides different kinds of computing services in which users and enterprises are allowed to get access to the collectively tunable resources remotely with the capabilities of storing, managing, and processing data in the cloud.

Load Balancing

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Load balancing is an optimization technique that distributes incoming workload among all available resources in an effective way (Figure 1) to improve performance, maintain system firmness, and protect against system failures. These load balancing solutions can be hardware based or software-based

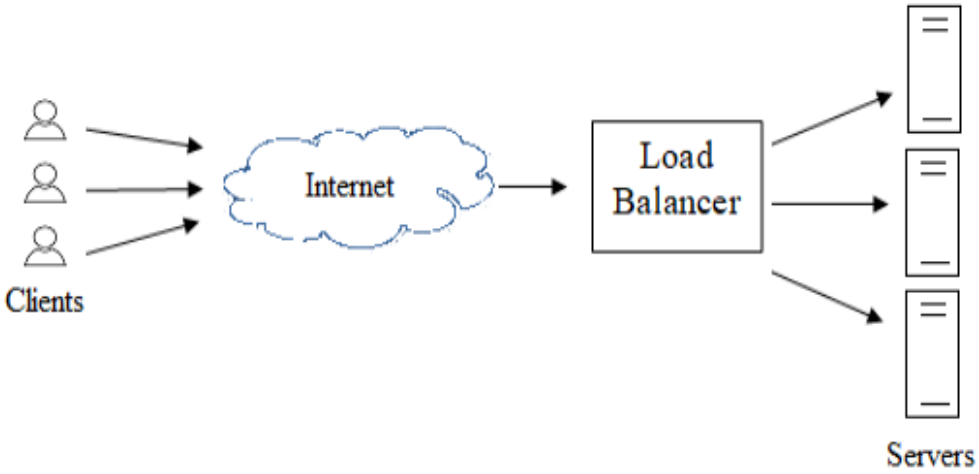

Figure 1 Load Balancing

- Hardware-based load balancers: These are the proprietary hardware boxes housed in a data center and the system is installed, tuned, and maintained by IT experts. Only large companies with big budgets can get benefits from this. As these load balancers cost more, the small firms cannot afford hardware-based load balancers. The major drawback of these load balancers is that they do not support cloud computing. This is because cloud providers do not allow proprietary hardware in their environment.
- Software-based load balancers: These are the software that runs on standard hardware and operating systems. Because they run on commodity software, they cost less compared to hardware-based solutions; even they are affordable by small firms. One can save up to 80% on software-based solutions compared to hardware solutions. [1] Hence, they are best suitable for cloud load balancing and can run like other software in the cloud.

The Balancing of load is one of the important issue in cloud computing. Now a days load balancing becomes an important challenge and concerns. The reasons are:

1. Enhancement of the Cloud Environment Performance
2. Focus on increasing output.
3. Speed up your responses
4. Reduce user expenses as much as possible Maximize output for input
5. Restrain Your Use of Energy

System performance may decrease, resources can't be used to their full potential, and response times might be negatively affected without load balancing. Cloud computing places a strain on resources including the memory, network, and processing power. In order to optimise the performance of the cloud's infrastructure, it is necessary to perform load adjustment, the process of distributing the workload among the available nodes. Load balancing [2] takes

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into account a number of factors, such as the need to optimise for things like throughput, throughput rate, resource usage, and communication latency.

Benefits of Load Balancer

The cloud load balancer provides the following benefits:

High performance: The load balancing techniques are easy to implement and they cost less compared to their counterparts. Hence, organizations can work on applications with better performance at a lower cost.

Handle failovers: Whenever a server fails, the loads are moved from that server to an alternative by the load balancer. The user's experience no interruption in their work.

Handle sudden traffic burst: During peak hours there may be a sudden increase in traffic. In such a situation traffic is distributed among available servers to get maximum results with a minimum response time.

Increased scalability: In case of a sudden traffic bust, the current servers are not capable of handling the traffic, the load balancers either add power to the existing servers or add few more servers to handle the traffic. During the non-peak time, these servers are scaled out to save money.

The cloud load balancers use efficient scheduling algorithms to distribute load among all resources in an effective way. These algorithms are classified into different categories either based on the process initiation or based on the system state (Figure 2).

Based on the initiation process they are categorized into three groups, namely:

Sender initiated: Here the load balancing process is initiated by the sender after identifying the overloaded nodes.

Receiver Initiated: The receiver identifies the overloaded nodes and initiates a load balancing process. Symmetric: This is the combination of the above two categories.

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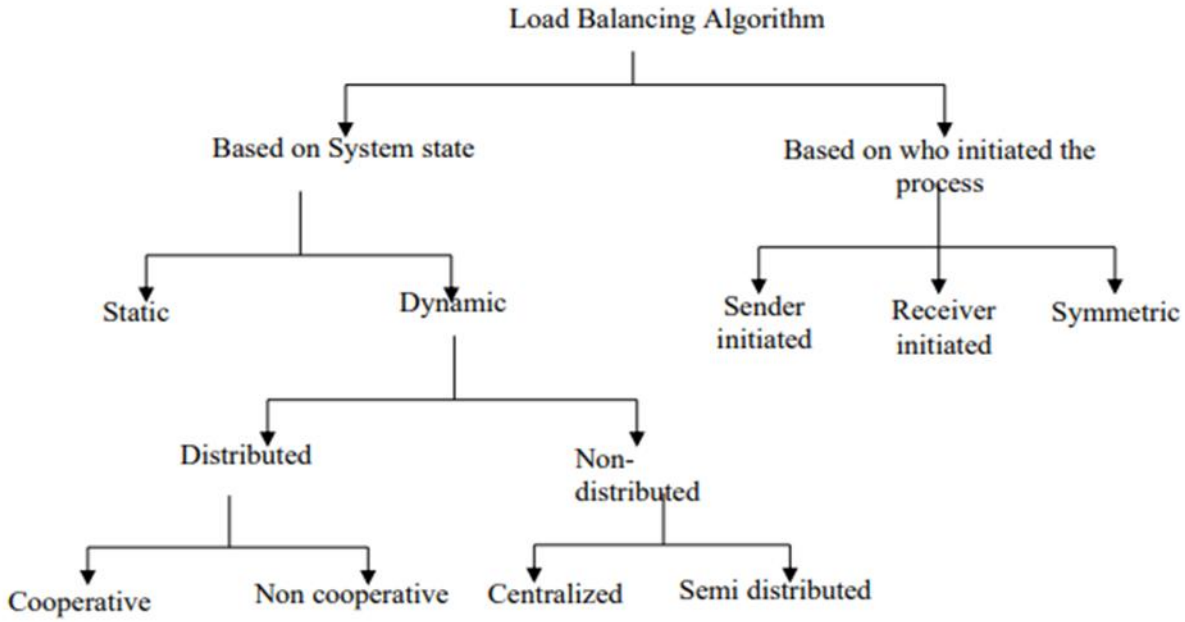

Figure 2 Categories of the load [3] balancing algorithm

Literature Review

Cloud Computing supervises a variety of virtualized resources, which makes Scheduling and load balancing a critical component. The primary goal of the computation of Scheduling is to improve the execution, improve the nature of administration, maintain productivity and decency between employments, and reduce execution costs. Customary computations of scheduling are not enough to achieve these destinations. Therefore, several improved algorithms were suggested to overcome these constraints. The future technology is cloud computing. Therefore, it is quite necessary to schedule cloud computing tasks, so that response time is minimum and performance is maximized. Various inventors took the problem of scheduling and saw it as difficult as NP ("Non-Polynomial"). With the use of different methodologies, writers proposed a few frameworks to tackle the scheduling issue, and among the timetables that achieved the best results are: Davis suggested Job Shop Problem in 1985 with the utilization of Genetic Algorithm. Different such works are adjacent to the utilization of headway techniques.

[4] This study proposes a novel technique for load balancing in the cloud, with the goal of evenly distributing the load across all servers. We analysed how resource management in a cloud environment impacts the choices made during the design phase of a load-balancing algorithm for use in the cloud. One of the most important things a developer can do is to analyse different resource allocation strategies and VM load balancing options for the system. The study author provided specific strategies for managing the workload. Several low-execution-time algorithmic solutions exist for effective resource management.

[5] This article provides a concise overview of current cloud computing load balancing approaches and then evaluates them using a number of criteria, such as response time & data processing time. Every IT professional faces the dual hurdles of time and money while working to improve cloud-based businesses' performance. In the research, the authors analyse the efficiency of two different algorithms. Requested times for Round Robin and Throttled Load balancing are equivalent, indicating that switching between the two algorithms has little impact on data centre response times.

In the experimental study, we computed the cost analysis that was shown for each of the algorithms. When comparing the two techniques, Throttled Load balancing is more cost-effective for the load balancing on the cloud data centres since it reduces the cost of consumption per hour of virtual machines.

[6] Two techniques are proposed in this study to evenly distribute cloud system workload across available resources. The need for virtual machines is expected to rise despite the prevalence of low-load systems. The quickest way to complete all tasks is to consolidate them onto a single virtual machine and reduce the number of high-priority instances. Our research system would be strengthened, and time spent doing it will be cut down and resources optimised. In the beginning, when the new request is made, the amount of Work allotted will be less than the time it takes to complete the VM. The ability to reload virtual machines (VMs) will be disabled at some point in the future in favour of working with VMs already under load. Priority tasks are a behaviour motivated by honey. In this method of using prioritised algorithms, even part-time work will be counted as full-time for the purposes of determining whether or not a person is a virtual machine. The plan is designed so that the team involved has better tools at their disposal. Improving response times and overall system performance in the cloud computing setting.

[7] To achieve quantifiable improvements in support utilisation and availability in cloud-computing environments, the author of this research suggested a novel effective load balancing approach based on the fuzzy logic and the Round Robin (RR) load balancing. When developing the load balancer's logical laws, it was also necessary to take into account the community's structure or the topology. The balanced load on data centres in cloud computing environments is evaluated using a fuzzy good method based on two criteria, the processor speed of the computer and the allocated load of the Virtual System (VM) of a machine. Overall performance evaluation's outcomes may lead to more efficient use of the resources by stabilising body weight while cutting down on processing time and enhancing normal response time.

[8] To distribute work fairly, the proposed approach sorts cloudlets by their Length (the number of instructions they contain) and the virtual machines by their processing capacity. After compiling a list of available virtual machines and cloudlets, the broker is asked to distribute them. In order to distribute resources, the broker uses a midpoint method to split the VM list and also the cloudlet list into smaller and smaller subsets of each other until there is only one cloudlet or the virtual machine left in the list. Jobs that can be completed with less processing power are not sent to machines with more processing power & vice versa because to this algorithm's careful resource allocation.

Methodology

In particular, task scheduling is significant because improper scheduling of tasks can prevent a cloud system from realizing its full potential and can offset the benefits of parallelization by causing significant underutilization of resources. As a result, the scheduling strategy is responsible for generating schedules that best use the cloud system resources to increase overall performance. [9] An excellent task scheduling method contributes to better system performance. An effective job scheduling method to use cloud computing resources and improve efficiency and performance is essential. Load balancing is an equally essential feature of cloud task scheduling. While certain VMs are overloaded, the Load needs to get shared with the under loaded VM's to achieve resource optimization for the proper completion of tasks.

Task scheduling system in cloud computing

In cloud computing, there are three tiers to the work scheduling mechanism:

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- A bundle of tasks (Cloudlets) provided by cloud users and waiting to be executed constitutes the first task level.
- The second layer of scheduling is accountable for allocating tasks to appropriate resources in order to maximise resource usage and minimise makespan. Makespan refers to the whole amount of time required to complete all jobs, from start to finish.
- At the third tier, virtual machines (VMs) carry out the processes shown in Figure 3.

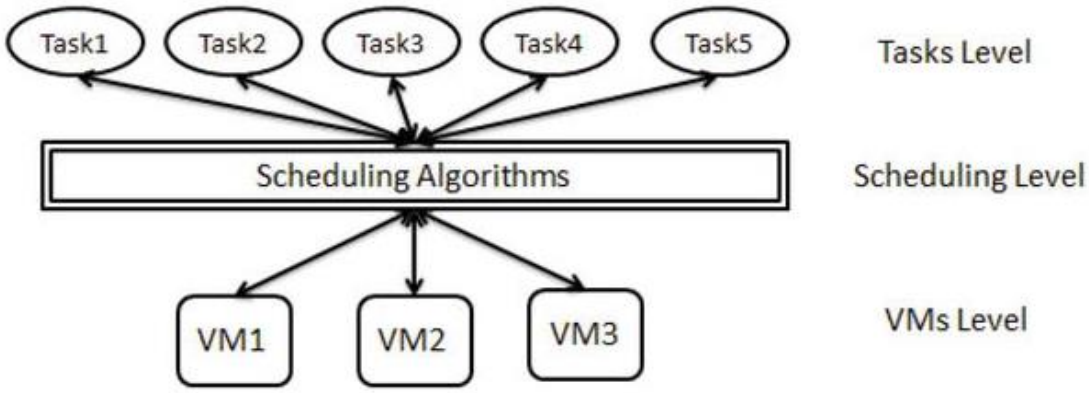

Figure 3 Task scheduling system.

The progression through these two stages of the level is as follows:

- Step one involves utilising a datacenter broker to locate and sort through all the available virtual machines (VMs), as well as gather status data pertaining to each of them.

After that, a virtual machine (VM) is chosen that is conducive to the work at hand.

The General Outline of Load Balancing Algorithms

Step 1: Initialize the list of VMs.

Step 2: Initialize the task/cloudlet list.

Step 3: Sort the tasks utilizing File output size, Cloudlet Length, and File input size.

Step 4: Sort the virtual machines using MIPS and Granularity Size.

Step 5: Submit sorted list and virtual machine list to Broker.

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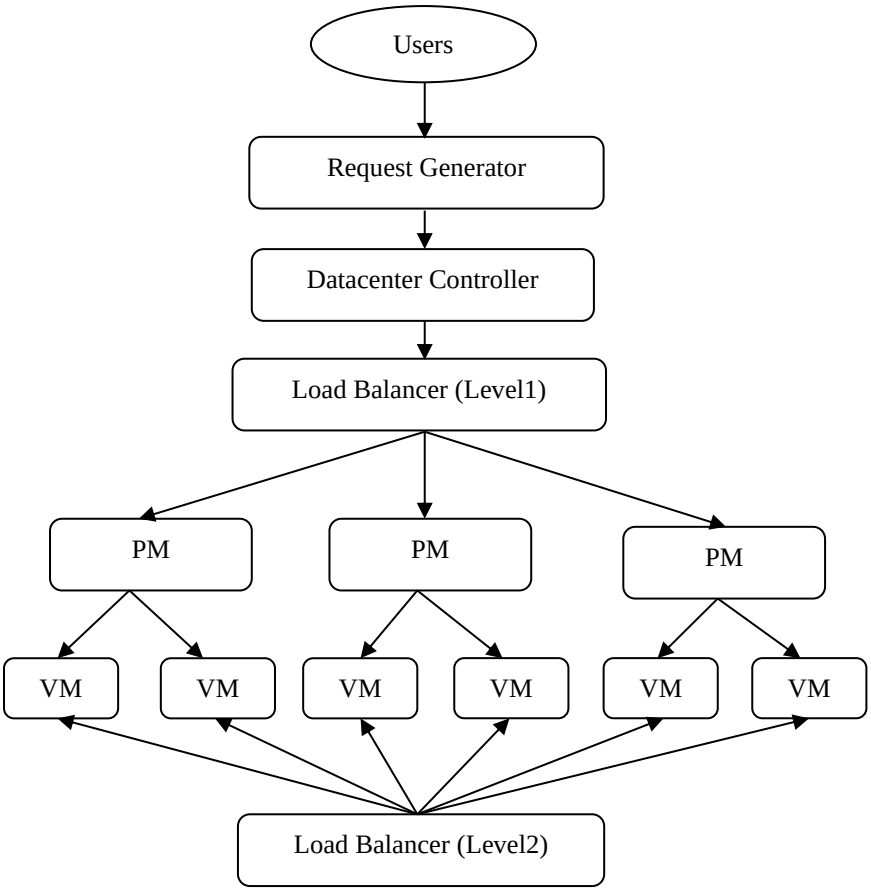

Figure 4 General Architecture of Load Balancing

The Developed algorithms have been implemented in the Cloudsim 3.0.3 framework using Netbeans 7.4 and JDK 1.8 as an IDE to run the cloudsim simulator. The experiments are undertaken on a system with an Intel core i5 -2450 M processor with a clock speed of 2.50 GHz and the main memory of 4 GB.

Table 1 & 2 presents the basic input values taken for the simulation using the cloudsim simulator.

Cloudsim Specification for experimental analysis

Table 1 VM properties.

VM Id	VM MIPS	VM image size	Memory	No. of CPU	VMM
0	1000	1000	512	1	Xen
1	580	1000	256	1	Xen
2	700	1000	256	1	Xen
3	550	1000	512	1	Xen
4	400	1000	512	1	Xen
5	250	1000	512	1	Xen

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Table 2 Task properties.

Cloudlet Id	Length	No. of CPU
0	79424	1
1	26673	1
2	250802	1
3	396312	1
4	271127	1
5	75633	1
6	209101	1
7	253928	1
8	39667	1
9	20811	1

Result and Discussion

Five sets of SET 1, SET 2, SET 3, SET 4, SET 5, SET 6 and SET 7 data are analyzed. Different schedules are drawn up by different jobs and VMs.

Table 3 Schedules Details

Schedule	Tasks	Virtual machines	Datacenters
SET 1	0-10	6	4
SET 2	0-15	6	4
SET 3	0-20	6	4
SET 4	0-25	6	4
SET 5	0-30	6	4
SET 6	0-40	6	4
SET 7	0-50	6	4

Table 3 represents seven different schedule sets used for simulation. Each set considers tasks ranging from 0-50, virtual machines fixed to 6, and datacenters fixed to 4.

Analysis based on Makespan Time (MST)

Makespan is the total amount of time it takes for all of the tasks in a sequence to complete running. It is denoted as

$$\boldsymbol{MST = \max\{CT_{kl} | k \in T.\, k = 1, 2 \ldots n \text{ and } l \in VM.\, l = 1, 2 \ldots m\}} \quad (1)$$

The overall analysis is divided into five scenarios with six fixed virtual machines. Therefore each scheduler runs for seven different workloads ranging between 0 to 50 and is considered for comparative analysis. The compiled results of the performance parameter Makespan Time for the various proposed scheduling algorithms and existing algorithm have shown in Table 4.

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Table 4 Makespan Time Estimation of different loads for various algorithms with 6 virtual machines for scheduling algorithms.

Tasks	RR	SJF	FCFS
10	179	221	184
15	222	378	223
20	312	369	347
25	382	475	403
30	435	463	492
40	449	524	458
50	462	667	467

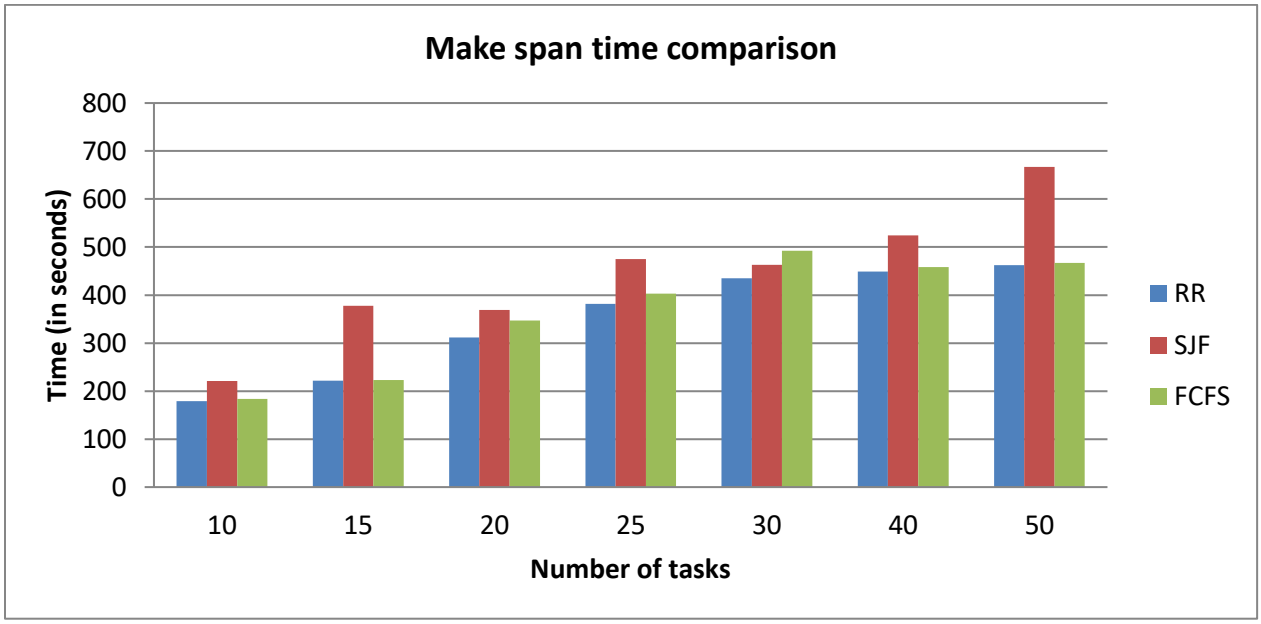

Figure 5 Makespan time comparison proposed algorithm with another existing algorithm at VM6.

Round Robin takes minimum time to complete number of task. Hence compare our proposed work with existing work.

Table 5 Compare proposed work with existing method.

Tasks	Proposed Algorithm	Existing Algorithm
10	179	518
15	222	544
20	312	559
25	382	588
30	435	654
40	449	884
50	462	1096

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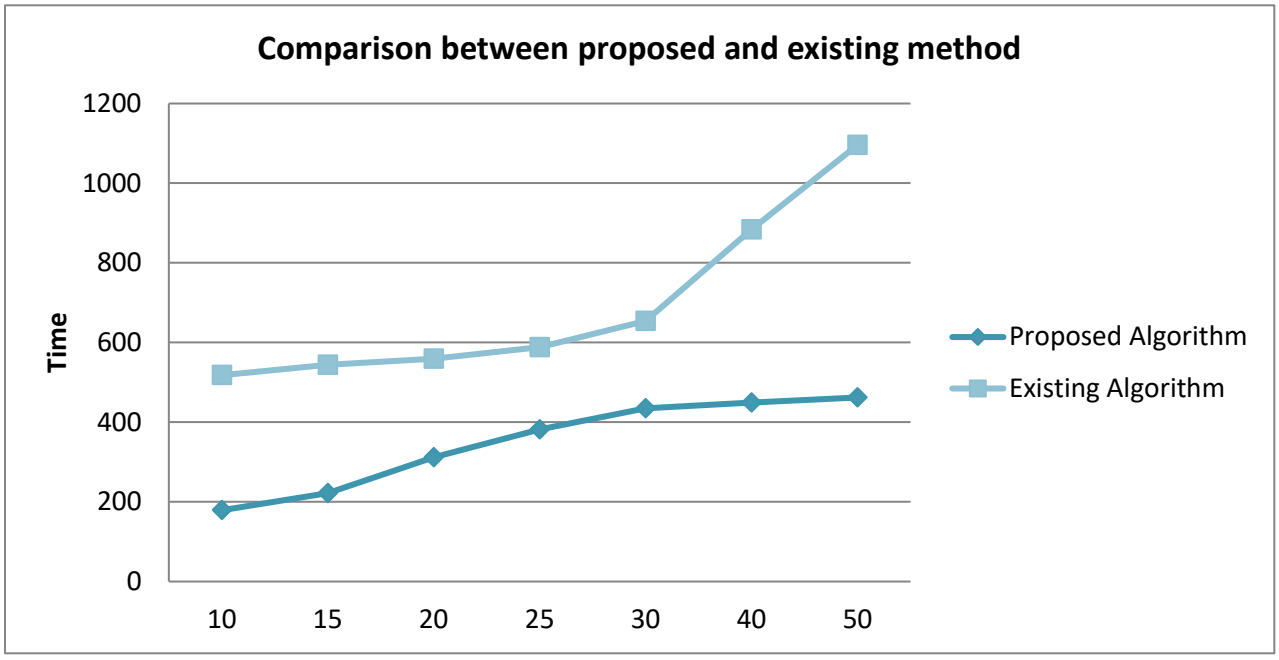

Figure 6 Comparison between proposed and existing method

Fig. 5 and Table 5 illustrate the Performance Improvement Percentage of Proposed Algorithms over Existing Algorithms. The makespan time improvement in proposed algorithms Round Robin. Our experimental evaluation exhibits that the round robin is better than existing algorithms in term of Performance Improvement Percentage.

Conclusion

The task scheduling with load balancing Problem in cloud environment has been considered to improve the performance parameter termed Make Span Time. Three well-known algorithms short job first scheduling (SJF), first come first service (FCFS), and Round Robin, from the literature, has been considered to define the load balancing algorithms. Seven distinct workloads, with task counts varying from 0 to 50, and the constant number of the virtual machines are used to calculate the algorithms' performance.

Some of the significant findings from the present work have been stated as follows:

- The in-depth analysis of task scheduling as well as load balancing algorithms in cloud computing environment has been performed.
- This study proposes three improved cloud scheduling and load balancing short job first scheduling (SJF), first come first service (FCFS), and Round Robin.
- Performance parameter have been studied and analyzed for tasks ranging from 0-50 and fixed virtual machines.

The performance of proposed load balancing algorithms have been compared with state-of-art scheduling load balancing algorithms in terms of makespan time.

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