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Comparative Performance Evaluations of Round Robin and Power Aware Load-Balancing Algorithms in Cloud Environment

[1]Basaky, F.D., [2]Omonori, J.D., [3]Durotola, I.T. & [4]Ogbe, K.U.
[1] Department of Computer Science, Salem University, Lokoja, Kogi State, Nigeria.
[2,3]Maharishi International University, Fairfield, Iowa USA
[4]Prince Abubakar Audu University Anigba, Kogi State, Nigeria
E-mails: [1]fdbasaky@gmail.com; [2]jomonori@miu.edu; [4]ogbekingsley90@gmail.com
Phone: +2348158882544

ABSTRACT

Cloud computing is no longer abstract, as it provides real-time and virtual hosting solutions. Instead of being accessible via physical hardware alone, all servers, software, and networks are hosted off-premises in the cloud. It's a real-time virtual environment distributed across multiple servers simultaneously. These capabilities are made possible by its existing services. The availability of free cloud services allows for the development of applications like cloud-based security surveillance and detective strategies built on military methodologies. Furthermore, unlimited storage capacity makes cloud computing a more cost-effective, reliable, and result-oriented solution, particularly with its pay-as-you-go model. This incomparable model highlights the limitations of the Nation's security system, which depends solely on traditional satellites, local data centers, and unreliable hardware (such as desktop computers and CCTV cameras) that are connected via a remote server. Traditional servers are typically installed on high-risk physical premises, often with staff who may lack the specialized training required to manage the hardware effectively. Load balancing (LB) is one of the major challenges in cloud computing, used to balance the workload of cloud services. This study provides a performance evaluation of the Round Robin and Power-Aware load balancing algorithms. The overall performance rating of the Power-Aware algorithm, when applied to nine qualitative metrics, was 70.77%, while that of Round Robin was 98.68%. The results indicate that the Round Robin algorithm was a more effective algorithm than the Power-Aware one.

Keywords: Round Robin, Power Aware, Load Balancing, Algorithms, Cloud Environment

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1. INTRODUCTION

Cloud Computing is an important technology that provides essential private and public services. Because of its exponential growth over the past decade, multiple corporations and business sectors have transitioned to the cloud to ensure transparency, scalability, and accessibility (Dalia et al., 2022). Most organizations are moving to the cloud due to cost savings and complex resource distribution. In a cloud environment, the corresponding infrastructure is managed and handled by cloud providers (Agarwal and Srivastava, 2017; El Karadawy et al., 2020). Cloud computing has transformed how organizations and individuals access, store, and process data by providing scalable, on-demand resources over the internet. Its rapid adoption is driven by cost efficiency, flexibility, and the ability to support a wide range of applications, from business operations to artificial intelligence. Cloud computing is used across diverse sectors like education, government, and agriculture.

However, challenges in cloud computing require resolution before the true potential of the cloud can be fully implemented. Among these challenges, resource management, specifically Load Balancing (LB), has become a significant concern. Load balancing is a technique for spreading the burden on several machine assets via network connections to achieve optimum resource efficiency and minimal data analysis time, thus preventing server overloading. Load balancing implies that at any moment, all processors in the system, as well as in the network, will perform almost the same amount of work (Shahid et al., 2032). This study provides a performance evaluation of the Round Robin and Power-Aware load balancing algorithms.

2. METHODOLOGY ADOPTED

The techniques adopted in this work focus on the concepts of Object-Oriented Analysis and Design (OOAD). Object-Oriented Analysis depicts the definition of classes and the manner in which they are used with one another to effect customer requirements. Unified Modeling Language (UML) and the Unified Process are predominantly features of Object-Oriented Analysis. OOAD is used because the model being proposed was deployed using a Java platform-independent, class-based system, and OOAD is most appropriate for developing models that are either desktop-based applications or web-based. The application to test the proposed model focused on the cloud computing load balancing technique or approach, where CPU resources are required for utilization. This process can be best described using a Case Diagram and Sequence Diagram which can depict the process easily.

The Object-Oriented Design Analysis (OODA) concept is modeled from two different respects: the logical structure of the system and the physical structure of the system. Both static and dynamic structures are modeled in each respect. OODA provides a variety of procedures that are used to accomplish these two important jobs.

Based on this research work, the methodology was narrowed down in terms of Central Processing Unit (CPU) resource utilization, specifically the allocation policy broker or task in load balancing in cloud computing technique or metrics.

2.1 Load balancing in Cloud Computing Environment

This research work provides the details approach of Load Balancing in cloud computing environment, based on this fact the process involves the ability to reassigning the total load to the individual nodes of the collective system to make resource utilization effective and to improve the response time of the job, simultaneously removing a condition in which some of the nodes are over loaded while some others are under loaded. A load balancing algorithm which is dynamic in nature does not consider the previous state or behavior of the system, that is, it depends on the present behavior of the system.

2.2 Cloud Computing Quantitative Load Balancing Process

Some of the steps used for evaluating a cloud computing virtual machine learning involves:

- **CPU Utilization:** The total percentage of time for which the CPU was utilized or used (i.e., was not idle).
- **Throughput:** Total no. of tasks executed (or requests served) per unit time.
- **Response Time:** The time spent by a request in the waiting queue until it gets the first time to use the CPU.
- **Waiting Time:** The total time spent by the request waiting in the ready queue after the first response from CPU.
- **Turnaround Time:** The total time taken by a request to get completely served, including its response time, waiting time and service time.
- **Fairness:** The principle that states that every request should get equal share of CPU time.
- **Resource Cost:** The total cost of the resources acquired or used for the servicing of requests by various cloud consumers.

The main goal is to maximize CPU utilization and throughput, minimize response time, waiting time, turnaround time, and resource cost, and adhere to the fairness principle.

2.3 Cloud simulation tools

This section has looked at the detailed concepts of commonly used cloud computing simulation tools and discussed their main features. The CloudSim project has found widespread use in both research-based and industry-based cloud development. CloudSim provides a generalized framework for conducting experiments according to specific design issues, which can be seamlessly applied to the offered generalized framework. With its earlier versions based on GridSim, CloudSim was developed by the GRIDS laboratory of the University of Melbourne to model and simulate various cloud computing infrastructures.

In its later versions and in-depth re-implementation, CloudSim includes a full implementation of its own kernel to eliminate its reliance on GridSim. Conceptually, CloudSim, on one side, offers classes representing data centers, physical hosts, virtual machines, services to be executed in the data centers, users of cloud services, internal data center networks, and energy consumption of physical hosts and data center elements. On the other side, CloudSim supports dynamic workloads and the insertion of simulation elements. It also provides message-passing applications and data center work topology. In addition, CloudSim supports the modeling and simulation of different cloud computing environments, as well as the simulation of many data centers. Furthermore, evidence in literature suggests that CloudSim is capable of instantiating 100,000 machines in less than 5 minutes. It further enables studying on allocation policies and migrations of virtual machines (VMs), which is very useful for many researchers in the field.

2.4 Algorithm Design

- **Step1:** Initialize the Data Center Broker and initialize the status tables for all Virtual Machines (VMs) and Cloudlets, including the states of existing cloud resources and qualitative metrics. initialization, no Cloudlets are allocated to any VM.
- **Step2:** When a request to allocate a new Cloudlet arrives at the Data Center Broker: The Data Center Broker analyzes the VM status table. For each VM, the total expected execution time is calculated by summing the execution time of all existing Cloudlets currently in its queue plus the expected execution time of the new Cloudlet being prepared for submission. The VM with the smallest expected total processing time is chosen to submit the new Cloudlet. Tie-breaker: If multiple VMs share the smallest expected processing time, the first available VM is selected.
- **Step 3:** *The selected Virtual Machine ID is sent back to the Data Center Broker. The Data Center Broker then submits the new Cloudlet to the VM associated with that ID.*
- ***Step 4:*** *The Data Center Broker notifies the system about the new allocation and updates the status tables for the VMs and Cloudlets accordingly.*
- ***Step 5:*** *When the VM completes processing the Cloudlet request and the Data Center Broker receives the response: The Data Center Broker updates the Cloudlet's status table as completed. The completed Cloudlet is removed/reduced from the status table (i.e., removed from the VM's queue).*
- ***Step 6:*** *Go back to Step 2 to process the next incoming Cloudlet request.*

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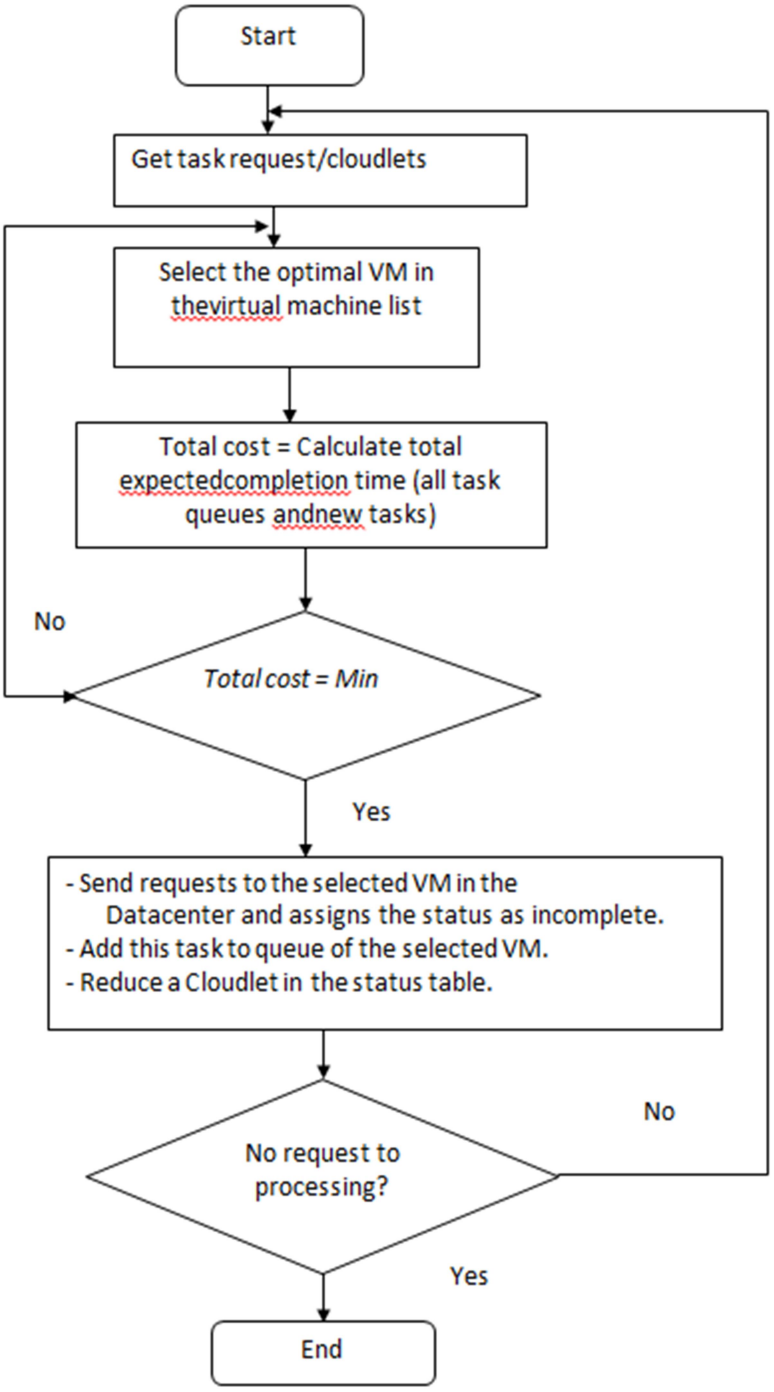

Figure 1: System Flow Chat

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3. RESULTs

3.1 A Comparative Study of Round Robin and Power Aware Load Balancing Algorithms

3.1.1 A Qualitative Metrics For Round Robin

This metric was used to compute the nine qualitative metrics of cloud computing to evaluate the performance of the Round Robin load balancing algorithm. The analysis shows that Round Robin achieved a 98% evaluation score with respect to the cloud resource allocation factor. Below is the module that controls the Round Robin qualitative metrics.

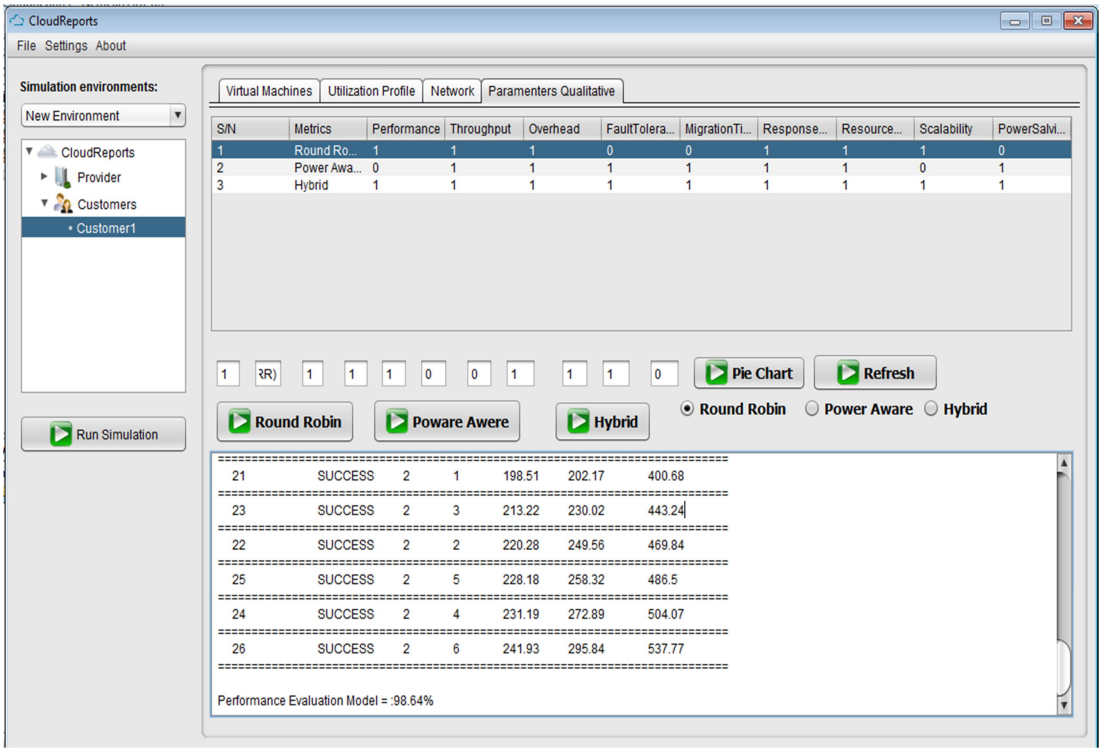

Figure 1: Qualitative Metric for Round Robin

Figure 1 , shows the performance evaluation of the Round Robin algorithm when applied to nine qualitative metrics. Based on these results, we were able to build the model for load balancing in a cloud computing system using the proposed techniques developed for this work.

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3.1.2 Qualitative Metrics for Power Aware

This metric was used to compute the nine qualitative metrics of cloud computing for evaluating the performance of the Power-Aware load balancing algorithm. The analysis shows that Power-Aware achieved a 70% evaluation score.

This score is primarily attributed to the redistribution or reallocation of idle cloud nodes during the execution, which focuses on minimizing energy consumption/utilization with respect to the cloud resource allocation factor. Below is the module for the Power-Aware algorithm.

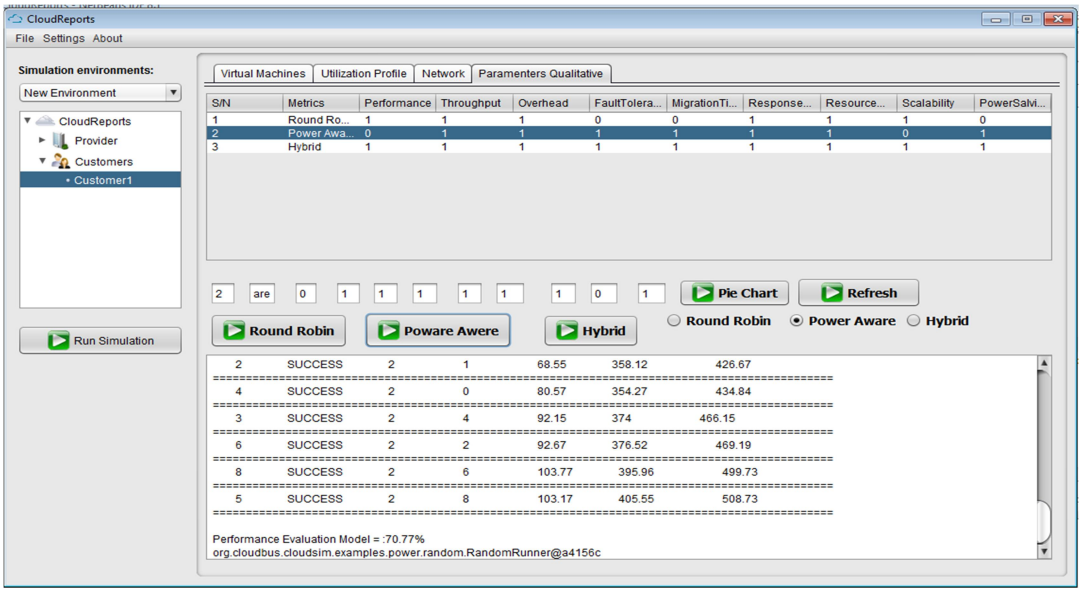

Figure 2: Qualitative Metrics for Power Aware

Figure 2 , shows the performance evaluation of the Power-Aware algorithm when applied to nine qualitative metrics. Based on these results, we were able to build the load balancing model in a cloud computing system with respect to the proposed technique used for this dissertation.

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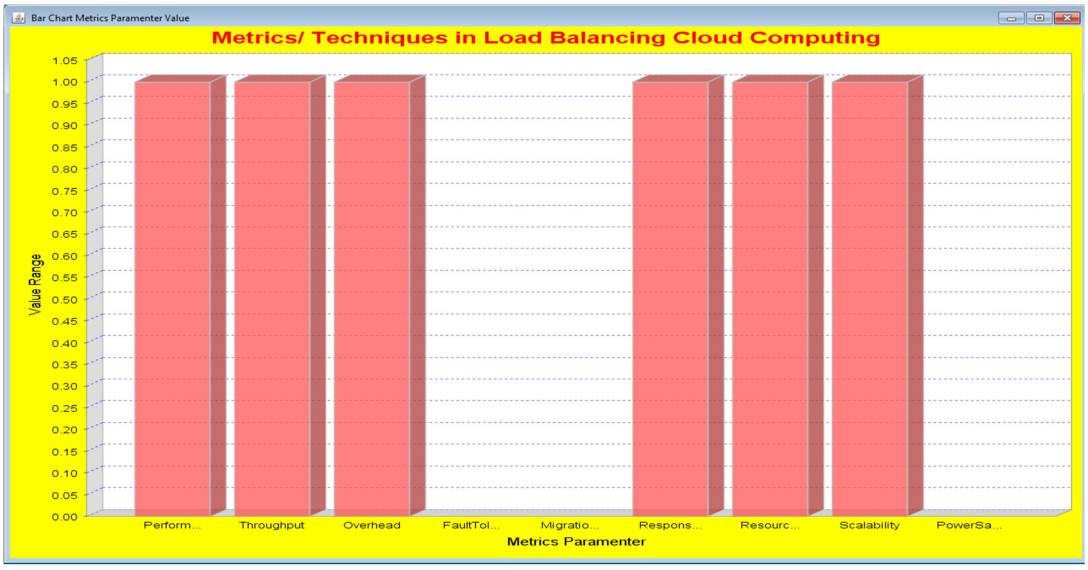

Figure 3. Qualitative metrics for Round Robin

Figure 3, which shows the qualitative metrics for Round Robin, indicates that fault tolerance, migration, and power saving were absent from the analysis, respectively.

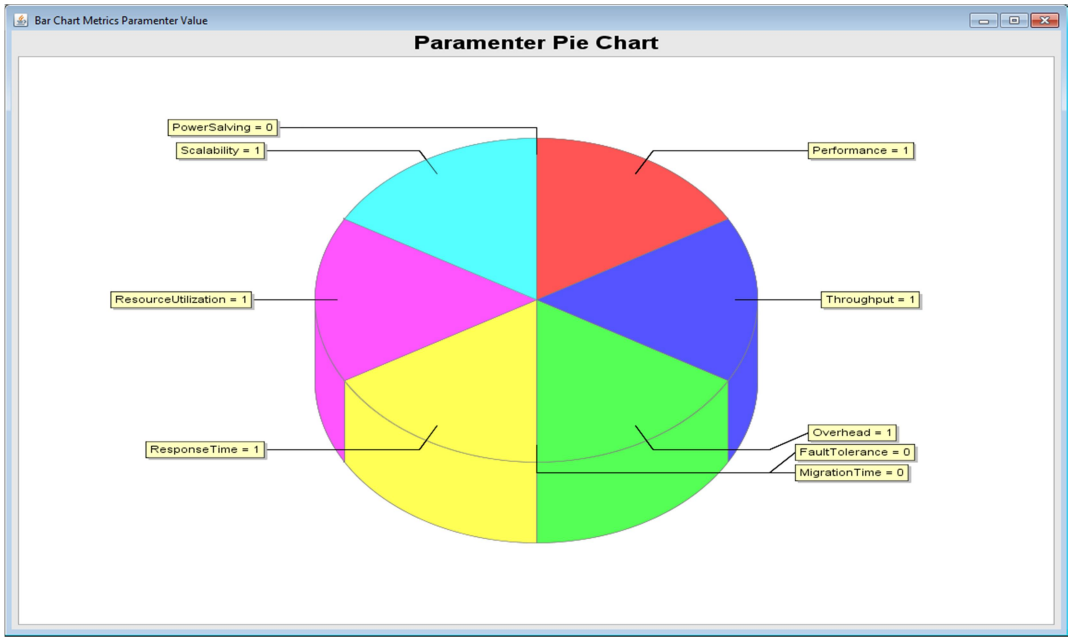

Figure 5: Round Robin Qualitative metrics

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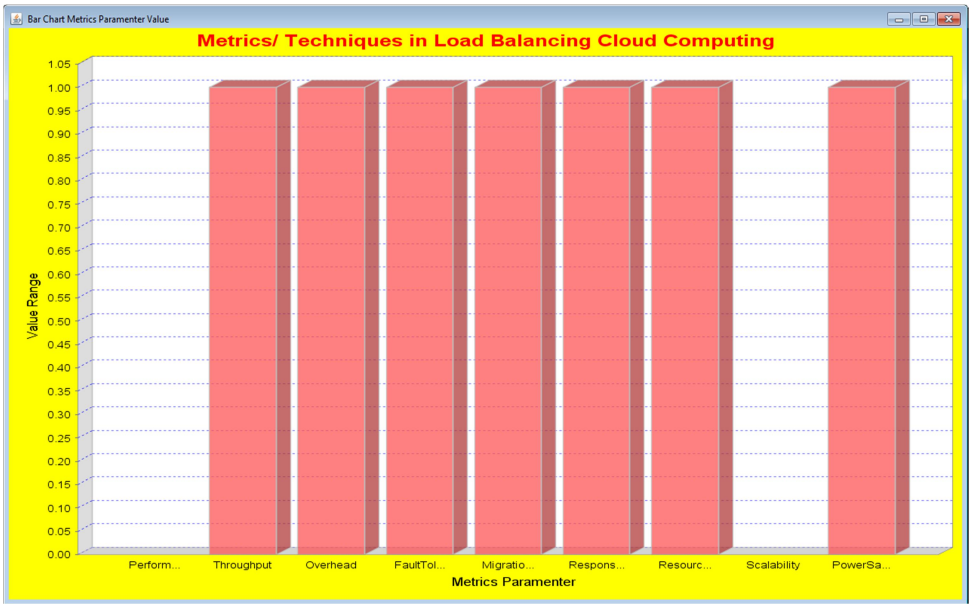

Figure 5: Qualitative metrics for Poware aware

Figure 5 , which displays the qualitative metrics for Power-Aware load balancing, indicates that performance and scalability were absent from the evaluation, respectively.

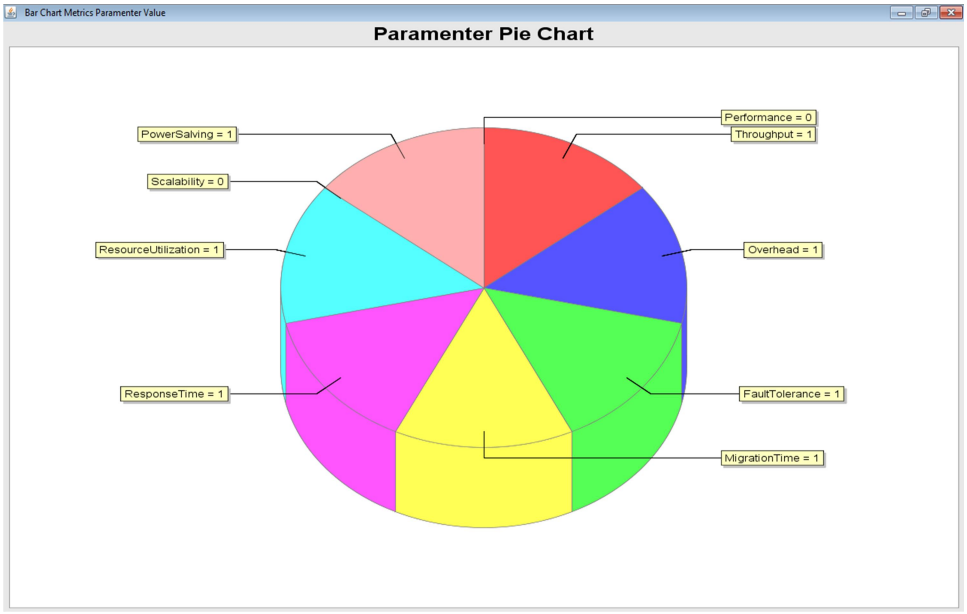

Figure 6: Power Aware Qualitative metrics

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Table 1 : Model Performance Evaluation for Round Robin

Algorithm	Round Robin

Cloudlet ID	STATUS	Data center ID	VM ID	Time	Start Time	Finish Time
0	SUCCESS	2	0	41.83	0.1	41.93
1	SUCCESS	2	1	68.55	0.1	68.65
3	SUCCESS	2	3	82.2	0.1	82.3
2	SUCCESS	2	2	92.88	0.1	92.98
5	SUCCESS	2	5	96.09	0.1	96.19
4	SUCCESS	2	4	104.8	0.1	104.9
7	SUCCESS	2	7	110.2	0.1	110.3
6	SUCCESS	2	6	116.52	0.1	116.62
9	SUCCESS	2	9	124.55	0.1	124.65
8	SUCCESS	2	8	128.06	0.1	128.16
10	SUCCESS	2	0	144.99	41.93	186.92
11	SUCCESS	2	1	133.53	68.65	202.17
13	SUCCESS	2	3	147.71	82.3	230.02
12	SUCCESS	2	2	156.58	92.98	249.56
15	SUCCESS	2	5	162.13	96.19	258.32

	14	SUCCESS	2	4	167.99	104.9	272.89
	17	SUCCESS	2	7	176.79	110.3	287.09
	16	SUCCESS	2	6	179.23	116.62	295.84
	19	SUCCESS	2	9	191.69	124.65	316.34
	18	SUCCESS	2	8	190.28	128.16	318.44
	20	SUCCESS	2	0	209.19	186.92	396.11
	21	SUCCESS	2	1	198.51	202.17	400.68
	23	SUCCESS	2	3	213.22	230.02	443.24
	22	SUCCESS	2	2	220.28	249.56	469.84
	25	SUCCESS	2	5	228.18	258.32	486.5
	24	SUCCESS	2	4	231.19	272.89	504.07
	26	SUCCESS	2	6	241.93	295.84	537.77
Performance Accuracy	98.64%						

Table 2: Model Performance Evaluation for Power Aware

Algorithm	Power Aware

Cloudlet ID	STATUS	Data center ID	VM ID	Time	Start Time	Finish Time
17	SUCCESS	2	7	190.33	0.1	190.43
20	SUCCESS	2	9	191.69	0.1	191.79
19	SUCCESS	2	3	200.34	0.1	200.44
22	SUCCESS	2	5	201.76	0.1	201.86
21	SUCCESS	2	0	209.19	0.1	209.29
24	SUCCESS	2	1	211.5	0.1	211.6
23	SUCCESS	2	4	218.55	0.1	218.65
26	SUCCESS	2	2	220.06	0.1	220.16
25	SUCCESS	2	6	229.39	0.1	229.49
27	SUCCESS	2	8	240.06	0.1	240.16

	============================ 7 SUCCESS 2 7 123.74 190.43 314.17 ============================ 10 SUCCESS 2 9 124.55 191.79 316.34 ============================ 9 SUCCESS 2 3 134.83 200.44 335.27 ============================ 12 SUCCESS 2 5 135.71 201.86 337.58 ============================ 11 SUCCESS 2 0 144.98 209.29 354.27 ============================ 14 SUCCESS 2 1 146.52 211.6 358.12 ============================ 13 SUCCESS 2 4 155.35 218.65 374 ============================ 16 SUCCESS 2 2 156.36 220.16 376.52 ============================ 1 SUCCESS 2 3 42.68 335.27 377.95 ============================ 18 SUCCESS 2 6 166.47 229.49 395.96 ============================ 15 SUCCESS 2 8 165.39 240.16 405.55 ============================ 2 SUCCESS 2 1 68.55 358.12

	426.67					
	==========					
	4	SUCCESS	2	0	80.57	354.27
	434.84					
	==========					
	3	SUCCESS	2	4	92.15	374
	466.15					
	==========					
	6	SUCCESS	2	2	92.67	376.52
	469.19					
	==========					
	8	SUCCESS	2	6	103.77	395.96
	499.73					
	==========					
	5	SUCCESS	2	8	103.17	405.55
	508.73					
	==========					
Performance Accuracy	**70.77%**					

Table 3: Performance Model for Round Robin and Power Aware

Algorithm	Percentage
Round Robin	98.64%
Power Aware	70.77%

The data from Table 3 clearly illustrates the percentage performance of the two load balancing algorithms in the cloud computing system.

4. CONCLUSION

Cloud computing has transformed how organizations and individuals access, store, and process data by providing scalable, on-demand resources over the internet. Its rapid adoption is driven by cost efficiency, flexibility, and the ability to support a wide range of applications, from business operations to artificial intelligence. The percentage performance evaluation of the Power-Aware algorithm when applied to nine qualitative metrics was 70.77%, while that of Round Robin was 98.68%. The result indicates that the Round Robin algorithm was more effective than the Power-Aware algorithm.

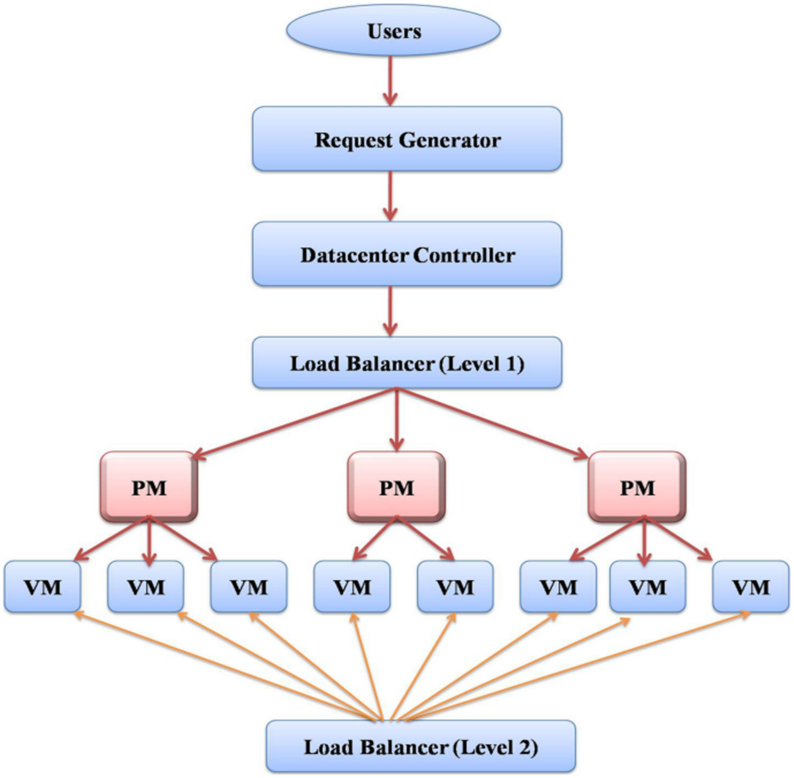

Fig 2: Two Level Load balancing Architecture

Source: https://journalofcloudcomputing.springeropen.com/articles/10.1186/s13677-019-0146-7

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