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Energy Efficient Extended FCFS Load Balancing In Data Centers of Cloud

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Abstract
Cloud computing guarantees the progress in the usage of computational resources and storage systems. Energy Efficient Cloud Computing system is an exigent issue in today's environment. Data storage in huge volumes can be employed in a remote location with the aid of a cloud computing system. The cloud also provides computational resources to acquire a service dynamically so as to meet the client demands. Cloud computing facilitates the consumers to complete their jobs in the virtual environment through pay-as-you- need basis. The critical necessity is to design a proper load balancing algorithm to meet the current demands of the client and to render the service yielding a quick response time thereby minimizing the execution cost in a cloud. The task of a proper scheduler is to achieve maximum throughput and effective resource utilization. The proposed work employs extended First Come First Server (FCFS) Load Balancing algorithm which performs an effective load scheduling addressing the various issues of the current demand of the cloud computing environment. The algorithm is focused on effective balancing of tasks based on the storage and retrieval of data in data centers so as to improve the efficiency of energy utilization. The chief chore of the cloud service providers is to condense the cost acquired for the energy utilization not only in the computational resources but also in the data centers. The proposed work has a focal point on minimization of energy both in the computing and storage resources with the help of effective load balancing technique.

Keywords: Cloud Computing, FCFS algorithm, Load Balancing, Data Center Storage systems, Energy Efficiency.

Introduction

Cloud Computing

Set of computers that are parallel and distributed systems are connected with each other with a concept of virtualization, dynamically provisioned and presented as unified computing service [11] [17] framed through arbitration between the service providers and customers. In cloud, load balancing is the center of attention, where the dynamic workload is disseminated among all the nodes in cloud, so as to avoid the maximum exertion by the majority of the nodes and least amount of tasks' to the lasting nodes. Thus, high user satisfaction and the substantial ratio of resource utilization, consequently perks up the overall performance and resource efficacy of the system. It thwarts the bottleneck in the system, which may occur due to disproportionate work load. The system should make sure that every computing system is assigned with equal amount of load. Consumption of resources and conservation of energy is not always a prime focus of deliberation in cloud computing. With proper load balancing, work resources can be equally split among all the components thus sinking the overall cost and resulting in green computing which is achieved by balancing the resource utilization ratio and the performance of a distributed system resulting in the reduction of the energy consumption and carbon footprint.

Green Computing

A habitual implementation of distinct theories and strategies to improve the ability of computing resources so as to diminish the energy disbursement and thereby sustain a green ambience is called green computing. In IT appliances, it acquires the competence to attain swift and extensible privilege to high-end computing potentialities [12] [18] and for this cloud environment provides a framework of computing with data centers helping the clients to have paid access to the data based on the request made. Green computing includes the implementation of best practices, such as energy efficiency central processing units, peripherals and servers. In addition green technology aims to reduce resource consumption and improve the disposal of electronic waste .The impulse of the survey of existing load balancing techniques in cloud computing environment is to support the novice researcher to add novelty in developing more efficient

• *Energy Utilization reduction ratio:*
Load balancing provides assistance in reducing the burning of energy by balancing the workload across all the nodes of a cloud. By making the nodes active and using the resources effectively [13] [16], the energy conservation can be incorporated which in turn leads to a green environment.

• *Emission of Carbon traces reduction ratio:*
Energy consumption and carbon emission are directly proportional. More the energy consumed, higher is the evidence of carbon emission. By reducing the energy utilization with the help of Load balancing, the carbon discharge shall be curtailed, helping in achieving Green computing [14] [15].

Literature Review

Dynamic Resource Allocation (DRA) algorithm [4] is proposed to stabilize the load and to use the resources in effect as well. They have contemplated on VM assignment and relocation amid the set of cooperating hosts. The load balancing algorithm proposed is either distributed or centralized. The vital scheme for the proposal is to evade overcrowding of tasks among the cooperating hosts and convene the dynamic load balancing. The conception of Green Power Management (GPM) is initiated in order to administer the power consumption in data centers effectively. The idea of GPM is brought into effect through the categorization of load. The clusters crafted are dynamically right-sized according the arrival of the tasks. Migration and powering of hosts are also included to enhance the GPM effect when the CPU is underutilized.

The algorithm in [5] proposes dynamic load balancing to perk up the effectiveness in cloud computing environment. The mission primarily realized in this paper is to ensure the utilization of the CPU. If the consumption is a smaller amount, then the CPU can admit the load and hence a response is delivered. If in any case, the CPU utilization is high, there shall be a performance degrade also leading to overheating of the data centers. Thus the loads are reallocated to other servers to facilitate circumventing excessive utilization of the CPU concentrating on power – performance trade off.

The algorithm [6] is proposed to marshal energy efficiency in data centers in the cloud computing environment. The chief objective of this algorithm is to trade off between load and the power consumption. Overheating of resources shall pave the way to diminish the system's trustworthiness and device existence. Also an amplification in the power consumption leads to carbon dioxide emission. The algorithm involves 5 mechanism like observing the power system, algorithm for power optimization, manipulating the power consumption, reconfigurable temporal policy for tasks administration and feedback loop to organize an effective and dynamic load balancing in so doing curtailing the overheat acquired due to over usage.

The algorithm proposed [7] is to congregate the deadline restriction of the tasks while carrying out load balancing in the cloud computing. Resource provisioning and allocating the tasks to the best resource chosen is concentrated in this paper for undergoing load balancing in IaaS cloud. The algorithm utilizes the idea of Particle Swarm Optimization (PSO) that aims in lessening the overall execution cost at the same time meeting up the deadline constraints.

The power aware load balancing algorithm [8] proposed focuses on the proper selection of virtual machines in order to utilize the resources properly leading to energy conservation.

The novel algorithm discussed in [9] offers a nomenclature in concerning renewable energy in the data centers of the cloud using 5 input characteristics like incorporating generation sculpt and prediction scheme, capacity arrangement of green data center, intra data center tasks forecasting and load balancing diagonally among heterogeneously distributed data centers.

Green Scheduling (GC) [10] algorithm involving neural network schema for forecast in that way optimizing the server power consumption in the cloud. The algorithm utilizes bee colony optimization and ant colony optimization at that moment of load balancing. The load is categorized into low, medium and high which helps in the tasks segregation.

A stochastic program is employed in [19] which captures centre level load balancing, server level configuration and battery management guaranteeing QoS . A power-aware system management algorithm can change supply voltage and frequency at appropriate time seconds to optimize a combined consideration of performance and energy consumption. Dynamic power management at the operating system level provides supply voltage and clock frequency adjustment schemes implemented while tasks run. These energy conservation techniques explore the opportunities for tuning the energy delay tradeoff.

A natural solution to the prevailing problem in the cloud is to combine hedging and load distribution together to achieve an overall benefit which is discussed in this paper [20]. The combined approach at first decides on the appropriate amount of electricity to be purchased for a future date at each data center and then ensure full use of the purchased amount on that date by adding appropriate workload constraints in the GLB's optimization framework.

Run-queue sorting with frequency selection laid a foundation for memory aware job assignment proposed in [22]. Run-queue sorting is a scheduling algorithm which proposes time slice based multiprocessing that is an explicit category of cluster scheduling. As per the norms of ICT, the radio network accessing consumes much energy in an infrastructure and the cost spent for professionals of networks maintenance is less when compared to the cost delivered on energy consumption.

The focus on balancing data processing load based on network topology and disk space utilization of a cluster is discussed in as an earlier work to DRAW [21] whereas this paper focuses on data redistribution based on data semantics. By specifying the access patterns the data are redistributed in a corresponding way such that the best data access performance can be achieved. However it requires application developers to specify the data access pattern beforehand.

Existing System

The existing system [1] discusses about an examination of energy utilization in cloud computing. The analysis regards both the cloud models of public and private and embraces energy consumption in network in addition to data dispensation and data storage. It bestows an idea that energy expenditure in migration and switching can acquire a considerable proportion of total energy consumption in cloud computing. Cloud computing can facilitate more energy-efficient application of computing power, particularly when the operating loads are of less amount or occasional. On the other hand, under some state of affairs cloud computing can devour more energy than conventional computing where each user carries out all computing on own desktops.

A contemporary data center in the cloud has three main components: data storage, network and server. The data center unites the remaining network with the help a gateway router. The power consumption for data centers server was significantly high when compared to the power usage incurred in the data processing or computation [2]. The work outlines the functionality of the data center at the same time a few efficiency enhancement in cloud computing data centers over conventional data centers. Long-term storage of data in a data center is provided by hard disk arrays, together with associated equipment. Hard disks consist of sustaining functionality like caches, disk array controllers, disk inclusions, and superfluous power stores. The storage spaces in the data center are fused up and handling of hard disk is centrally synchronized.

Consolidation and common organization diminishes the number of hard disks employed, magnificently escalating the overall energy efficiency of storage. Additionally, files that are least accessed shall be stored in a different hard disk sequences [3]. These hard disks get into a low-power mode when present in idle state leading to small amount of energy consumption. To echo these gain in energy efficiency, the study characterizes storage power to the files that are accessed on a regular basis. While rarely used data collection are stored on a disk, the read process data rate and the time taken for the actual response is insufficient for service such as file hosting, which necessitates recurrent accesses to the file.

Such services that are required for accessing data files are cached in the main memory and also replicated in additional servers. These servers also carry out management of data centers and a high performance computing functioning in on-demand computing. The server performance depends on the computational features of the task being performed, including the floating-point functions, storage accesses, and parallel processing demands.

Clients in huge scale can share the storage and computing resources of a single server with the help of virtualization and server consolidation. This in turn reduces the number of servers used and proportionally enhances server deployment. Server initiation and the tasks balanced by the servers do not afford any information to the users/ clients. When the tasks arrival rate is on the low side, the servers are initiated to a low power mode option in order to reduce the energy utilization.

The servers involved in computation operation, hosting of files in the storage systems of data center are highly employed to achieve the goal of energy conservation through the concepts of virtualization, consolidation and low power mode actions. Data centers incorporate two tier aggregation networks. In the investigation, a two-tier aggregation network is considered for the storage systems. The existing system involves servers in more numbers to maintain storage systems separately and to monitor the load balancing as well. This involves significant server usage leading to overheating of computational resources and also affecting the storage systems in the data center.

Proposed System

The proposed work is designed for performance analysis in a heterogeneous distributed cloud environment. A research work is carried out to extend a strong formal foundation that facilitates the relevance of the existing system. To achieve this, practical basics and precise simulation setting are experimented to illuminate the performance of real-time systems in storage systems in the cloud data center. The main objectives of the proposed aimed in attaining the target are to minimize the number of servers involved in the storage functionalities of the data center and to balance the load as well. To examine the functionalities an Energy Efficient Load Balancing (EELB) using First-Come-First-Served (FCFS) strategy is offered in a simulated environment with a different range of workloads. In order to obtain a deep and detailed understanding of the behavior of such systems the workload of uploading and downloading of several tasks are taken into account which affects the storage systems mainly.

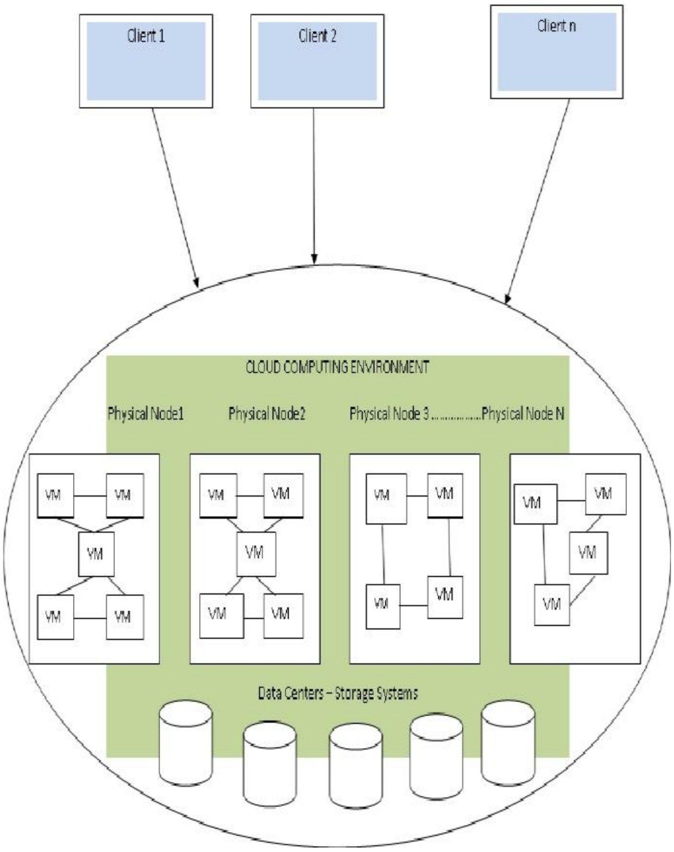


Figure 1: Architecture Diagram

The proposed system is designed to hold group model for workload distribution. In particular, these developments will be apposite to the course of action in which all servers may not be accessible concurrently on large-scale multi core platforms. The central idea of the proposed research work is to fabricate efficient scheduling algorithms which have the ability to settle on the clear-cut idea about the server usage including the storage computations there by maintain the numbers at a minimum level.

The load balancing policy implied should concentrate on the proper distribution of workload to the different servers based on the nature of the tasks and also should concentrate on the energy consumption involved in the storage systems of the data centers in the cloud computing environment. As an initiative, the proposed algorithm focuses on categorizing the type of storage while performing the load balancing of the uploading tasks. Additional servers' employment to categorize the files based on their nature and managing the data storage systems shall be curtailed to decrease the energy consumption by these servers. The servers involved in load balancing should take care of these additional tasks.

The nature of the files that are to be stored in the data centers are categorized based on the categories like frequently accessed, moderately accessed and rarely accessed. While performing load balancing, the server segregates the tasks of uploading files and stores in the appropriate locations of the data center storage systems. A simple FCFS strategy is extended to perform load balancing including the functionalities of task categorization, selecting the proper storage location, buffering the frequently accessed data files in the high speed caches and so on. The energy utilization of the storage system in the data center is significantly reduced when involving the same cluster of servers that offers load balancing. The additional servers involved in the storage management is evaded directing the diminishing the overheat occurrence in the servers and considerably saving the energy.

Energy Efficient Extended FCFS Load Balancing Algorithm:

In multiple clouds clustering, carrying out the tasks is done by the addressing the completion time constraints, which is a difficult chore. Offloading computation-intensive jobs on to the multiple cloud clusters may result in a decrease in the application completion time. This is made by considering the delay of uploading or downloading the data to or from the cloud. The total energy consumption in cloud clusters, including both the energy consumed by the processing units, the storage systems and the network components for offloading tasks is the objective function to be minimized. From the outlook of energy utilization, offloading tasks to the cloud saves the computation energy but it induces energy consumption in the communication units.

In general, the task scheduling techniques utilizes the task characteristics to perform the load balancing. In conventional task scheduling problems, there exists additional task precedence requirements across the multiple clouds and the local cores through wireless communication channels and to condense the total energy expense of an application with the privileges to use the computing resources on the cloud under a tough applications' execution, a time constrained scheduling algorithm is obligatory. The task description plays a vital part in the load balancing procedure of uploading and downloading. Based on the nature of the job, the server can enrich its performance by suitably picking the storage in the preliminary phase so as to trim down the waiting time in the storage system of the data center. Data storage and retrieval is taken care in analogous to the load balancing scheme thus minimizing the use of the computational resource in the storage space. Server consolidation and virtualization also helps the load balancing technique to properly decide the type of location while serving uploading tasks based on the file demand.

Hence the proposed approach increases the energy efficiency even though scheduling tasks across multiple cloud clusters both internally and externally. The proposed System intends to initiate a minimal delay task scheduling in the first phase by concentrating the characteristics of the tasks for the load of storage and retrieval using FCFS load balancing technique. Subsequently it concentrates on curtailing the energy consumption of the data servers by carefully analyzing the storage spot of the data file and performing the task execution. VM migration and server consolidation helps in doing so. Hence a strategy to introduce great energy reduction without violation of the application completion time constraint and involvement of additional servers for storage segregation can be implemented successfully through Energy Efficient Extended FCFS Load Balancing. The major objectives of the proposed system are

- To use a linear-time rescheduling algorithm for the task migrations in order to evade high time complexity.
- To design and develop an energy efficient scheduling algorithms that will figure out the precise least number of processors that must be assigned to load balancing thus guaranteeing the commitment of tasks' execution on clusters in which all processors are not simultaneously available and within the stipulated time.
- To categorize the tasks by observing the meta data of the file inclusions and data consolidations. This helps the system to complete the task easily there by reducing the working of the computational resource and decreasing the power consumption by the data servers.
- To formulate energy efficiency a constraint in both execution and storage resource consumption tasks.
- And finally make the idle processors to enter into sleep mode thereby improving the energy efficiency.

The proposed algorithm primarily involves the methodology of triggering the VMs to SLEEP mode when it is either in idle mode or when it is highly used. It is placed in a sleep mode when underutilized i.e. in idle state, as well as in the over utilized state. The VM draw on a little sum of energy when it has no load to process and at the same time the VM may come across over drainage of the battery power and overheating when it is highly utilized at peak demand. Thus the energy efficiency becomes a quandary. This state can be prevailed over by employing extended FCFS load balancing along with the inclusion of tasks' Meta data properties while performing tasks' execution. The energy consumption can be minimized and the performance can be maintained in a stable state. Once the VM is checked for the power state conditions, and the above methodologies are performed, the tasks are now scheduled for balancing to avoid overloading in the VMs. The load balancing technique is carried out by First Come First Served logic. In order to accommodate the demands of different users, they may offer different levels of quality for services. Then the cost per resource unit depends on the services selected by the user. In return, the user receives guarantees regarding the provided resources.

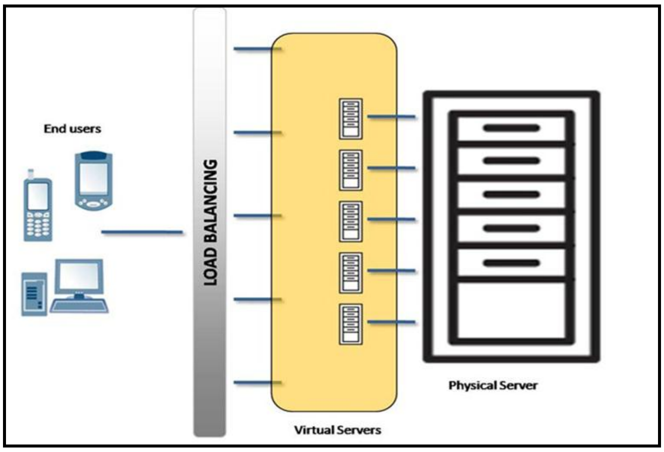


Figure 2: Outline Structure of Load Balancing

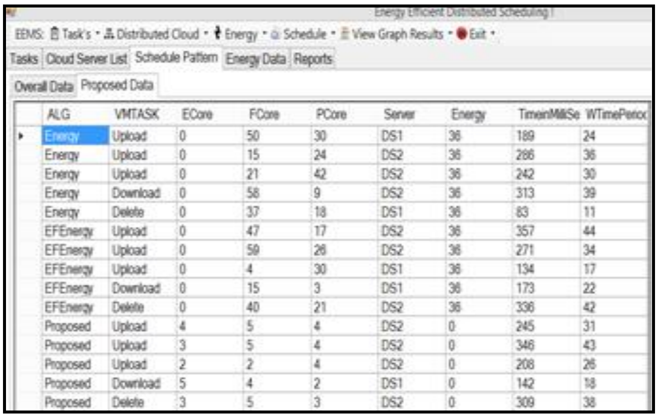
The figure 2 describes the common structure of the load balancing generally that occurs in the cloud computing environment. This paper momentarily confers load balancing, algorithms involving energy conservation in storage systems of data centers, later initiates a sort of load balancing algorithm that every node dispatches a corresponding request stream to affirm its real-time load for execution based on FCFS principle. The results of experimental analysis affirm the conservation of energy in data center storage system in conjunction with effective load balancing when compared to the existing system.

Load Balancing Using Energy Efficient Extended FCFS Algorithm:

The proposed algorithm is as below:
Begin
While arrival of tasks do
Observe the metadata about the tasks'.
Select the appropriate storage system location in the DC
Call EEEFCFS algorithm for tasks' storage / retrieval.
Utilize high speed cache data to perform the tasks of data retrieval.
If (server state == normal) then
Job balanced in the partition.
Else
Search for another Partition;
End if
Endwhile
End
EEEFCFS - Energy Efficient Extended FCFS Load Balancing Algorithm
Begin
Initialize the load parameters;
Initialize the VM parameters;
Start with power analysis;
Initialize Energy of VM
Determine the current energy of VM ;
Check CPUutil against the Energy of VM;
If (VM current energy == high || idle)
Then trigger the node to SLEEP
Else if (VM current energy == low || medium)
Then initiate the VMs to schedule process
Start with load analysis;
Calculate the load intensity using Balance Factor;
Post process results and visualization;
End

Experimental Analysis

Number of experiments was conducted to find out the throughput of the computational resource and the utilization of energy in the storage resource. The graphs displayed brings out an evidence that the power optimization can be achieved to a substantiate ration when compared to the existing algorithm. The power is deliberated as kilowatts(kw)/h, and the analysis considers various parameters like the number of virtual machines (VM), task meta data, server consolidation, VM migration, storage categorization, number of tasks executed and so on. Load balancing of the different set of tasks such as uploading (storage) and downloading (retrieval) is experimented using FCFS algorithm. The results are averaged for conducting the execution for more number of data stores in a varying range of 100 to 1000. Server consolidation is prepared all through the course of load balancing that comprises the assortment of proper storage location in the data center to place the data file and to analyze the characteristics of the tasks and the frequency of accessing the file type so as to place the same in the high speed caches. The power utilization can be significantly reduced when the energy spent on the data centers is condensed. When a proper load balancing is implied and the data files are segregated properly in the storage locations of the data centers, the energy conservation is made possible. The extended FCFS algorithm proposed in this paper concentrates on load balancing concurrent to the file distribution and efficient retrieval. The algorithm also performs server consolidation so as to make better utilization of the computational resources in an effective way which also helps in effective energy outflow. CloudSim framework helps the end users to undergo seamless archetype, replication and research on a Cloud computing environment. The experimental research work is undertaken in a cloudsim environment by providing necessary details like the number of tasks, metadata of the tasks, scheduling policies, CPU, RAM and Bandwidth parameters etc.



ALG	VMTASK	ECore	FCore	PCore	Server	Energy	TimeinMilliSe	WTimePeriod
Energy	Upload	0	50	30	DS1	36	189	24
Energy	Upload	0	15	24	DS2	36	286	36
Energy	Upload	0	21	42	DS2	36	242	30
Energy	Download	0	58	9	DS2	36	313	39
Energy	Delete	0	37	18	DS1	36	83	11
EFEnergy	Upload	0	47	17	DS2	36	357	44
EFEnergy	Upload	0	59	26	DS2	36	271	34
EFEnergy	Upload	0	4	30	DS1	36	134	17
EFEnergy	Download	0	15	3	DS1	36	173	22
EFEnergy	Delete	0	40	21	DS2	36	336	42
Proposed	Upload	4	5	4	DS2	0	245	31
Proposed	Upload	3	5	4	DS2	0	346	43
Proposed	Upload	2	2	4	DS2	0	208	26
Proposed	Download	5	4	2	DS1	0	142	18
Proposed	Delete	3	5	3	DS2	0	309	38

Figure 3: CPU utilization.

The graph shown in Fig.3 describes about the CPU utilization. The number of cores used in the processor, the execution and the response time of the multi – core processors in terms of the load conditions are analyzed. The results that have been observed shown a significant improvement in the utilization of CPU with respect to energy utilization when compared to the existing system.

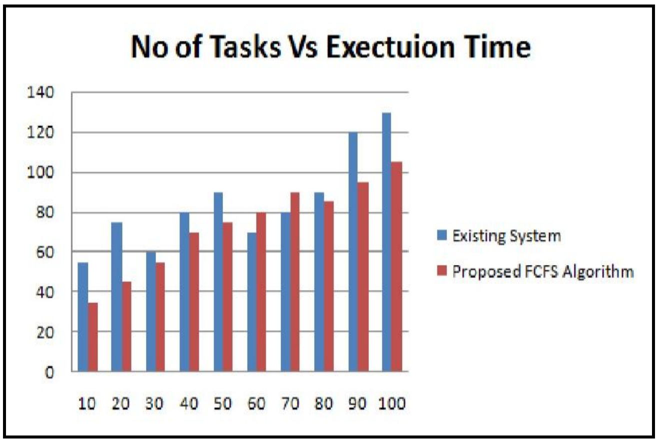


Figure 4: Performance analysis of the existing vs. proposed system in terms of execution time

The graph shown in Fig. 4 performs a comparative study of the existing system with the proposed extended FCFS Load Balancing algorithm with respect to the execution time. The response time and the system throughput are measured by provisioning varied number of tasks to the server involving the tasks of type downloading and uploading.

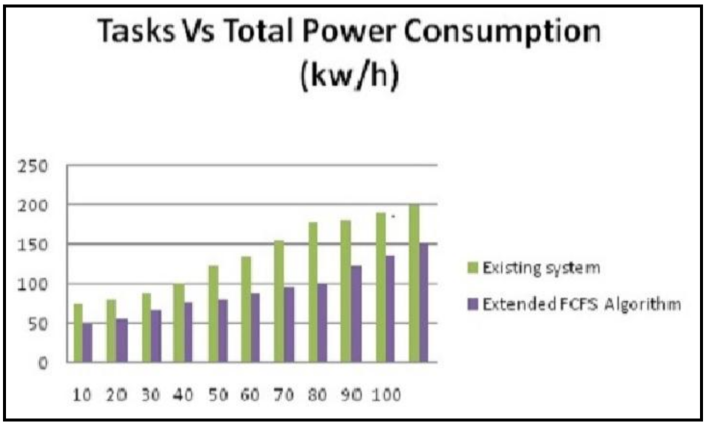


Figure 5: Comparative analysis of existing vs. proposed algorithm taking power consumption into consideration

The graph shown in Fig. 5 carries out a proportional cram of the existing system with the proposed extended FCFS Load Balancing algorithm with respect to the total amount of power consumed in kw/h for the ranged number of storage and retrieval tasks in the storage systems of the data center. The energy consumption in the data center is considerably diminished in the proposed algorithm thus leading to an energy efficient system leading to green computing in cloud.

Conclusion

The proposed work states the significance and implication of performance optimization and power diminution in cloud computing and also established the feasibility of studying the power-performance tradeoff for the servers involved in data center storage systems. A dynamic load balancing model for a cluster of heterogeneous multi-core servers with different sizes and speeds using extended FCFS algorithm is described. The FCFS load balancing algorithm embraces energy efficiency of storage systems and the computational resources of cloud. The experimental result shows a significant improvement in the response time, improvement in the segregation of storage space, energy conservation.

Future Enhancements

The future enhancement shall be introducing a machine learning technique for Load Balancing in the storage systems of the data centers in a cloud computing environment. When an effective machine learning algorithm is devised introducing a neural schema, the performance of the system significantly improves since the computing resources spend less amount of time in the load balancing and in the data storage as well. Thus the energy utilization in the cloud network can be magnificently reduced leading to an eco system.

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