Energy Optimize Consolidation Algorithm for Efficient Energy and Resource Utilization

Abhinandan M
CSE ,VTU, India,
abhimangaonkar123@gmail.com

Pradeep C
CSE ,VTU, India,
pradeepcharantimath1803@gmail.com

Maheshwari H
CSE ,VTU, India,
maheshwaridh2002@gmail.com

Murugesh G
CSE ,VTU, India,
mguddapur123@gmail.com

Nikhita K
CSE ,VTU, India,
nikhitakamate@gmail.com

***Abstract*— An imperative concern within cloud environments revolves around enhancing energy 3 efficiency by executing more tasks while minimizing power consumption. Virtual machine (VM) consolidation stands out as a widely adopted strategy for balancing performance and energy utilization. Although many existing techniques prioritize energy savings, they often entail performance trade-offs. Consolidation methods typically employ thresholds to identify overloaded and underutilized hosts, which can then be optimized to achieve an ideal balance between host utilization and usage of energy. In this investigation, we present an Energy Optimised Strategy (EOS) designed specifically for VM consolidation and migrations in cloud environments, aiming to reduce energy usage while increasing tasks productivity. Our approach utilizes the Performance to Power Ratio to establish upper thresholds for detecting overload conditions. Furthermore, EOS taking into all accounts from the data center workload utilization to set lower thresholds, thereby minimizing the need for VM migrations. Simulation results demonstrate that EOS facilitates energy-performance workload integration with less migration overhead and reduced energy consumption. The findings affirm that EOS effectively lowers energy usage ensure that user workload requirements remain uncompromised.**

Keywords—* *Virtual Machines, Power Consumption, Single and Two Phase Algorithms

I. Introduction

The idea of "computer clusters" serves as a metaphor for the internet, representing a simplified depiction of complex network infrastructures. Cloud computing represents a dynamic framework that streamlines the externalization of IT functions, including storage, computing procedures, and software distribution, through internet-based platforms. This shift towards service-oriented computing is primarily motivated by the streamlined management processes it offers, including software upgrades and bug fixes.

Additionally, Cloud-Computing enables rapid application development and testing, particularly benefiting smaller IT enterprises with limited infrastructure investments. A fundamental aspect of Cloud-Computing is its economy of scale, where costs per user and server utilization are optimized. The core principle involves distributing computing tasks across a multitude of dispersed computers rather than relying solely on local machines or remote servers. The primary objective is to furnish secure, efficient data retention, and network computing services cantered around the internet. Computational assets are aggregated, fostering a versatile application milieu conducive to the adaptive provisioning and redistribution of resources in response to varying levels of demand. Users can conveniently access computing resources over the online network according to their specific requirements, without the need to procure servers, software, or solutions individually.

II. WHY CLOUD-COMPTING REQURIES GREEN COMPTING

The escalating concern of global warming has underscored the significant environmental impact of cloud computing, attributed largely to the extensive infrastructure comprising numerous data centers. These data centers, integral to cloud operations, demand substantial power to function and process tasks, consequently emitting considerable heat and environmentally hazardous elements such as carbon dioxide. Power Usage Effectiveness (PUE) serves as a key metric for assessing the efficiency of data centers in terms of energy usage, with values ranging from 1.0 to infinity. A PUE of 1.0 denotes optimal energy utilization, where all power is directed towards equipment operation, resulting in 100% efficiency. Notable entities like Google, Facebook, and YouTube have achieved commendably low PUE values, with Google registering a PUE estimation of 1.13. However, higher PUE values indicate increased energy consumption and waste, posing significant environmental risks. Efforts to tackle environmental challenges have spurred the rise of Green Cloud computing, which aims to optimize processing efficiency while reducing energy consumption in cloud infrastructures. Sustainable development in cloud computing requires proactive measures to reduce energy wastage. Therefore, it is crucial to implement efficient resource management strategies to achieve the objectives of Green Cloud computing. This ensures the prudent allocation of cloud resources to meet the quality of service criteria outlined in Service Level Agreements (SLAs), while also reducing the overall energy footprint. Failure to address these 9 issues may result in increased energy consumption, especially as cloud computing interacts with increasingly prevalent front-end client devices, posing a significant threat to environmental sustainability..

III. LITERATURE REVIEW

The cited papers summarize the perspectives and discoveries of various researchers who have 5 delved into the realm of environmentally sustainable computing, with a focus on methods to preserve energy and safeguard the environment. We have utilized their findings as foundational knowledge for our own investigations and future studies, as outlined in Table 1.

Approach	Outlines	Advantages	Disadvantages	Conclusion
1.Study of green cloud computing.[1]	Green cloud, green broker,co2 emission diary,manager.	co2 emission diary provides best possible way to control co2 emission, and use less energy.	Everything depends on manager and manager is a main part, manager fails everything fails.	It eliminates problems in cloud, consumes less energy and reduces co2 emission .
2.Load balancing and power consumption management.[2]	job submission and scheduling algorithm, ant colony, bee colony	schedule the jobs according to availability of VM's, turn on or off CPUs	violation of service level agreement, slightly time consuming, depends on manager.	by switching on and off the CPU energy is saved, and security of green cloud is future work.
3.Power management in could computing.[3]	green cloud computing, green algorithm, task consolidation algorithm, VM migration.	reducing energy consumption by migrating VM, resource allocation.	putting the servers in sleep mode or on mode, little time consuming.	reduction in co2 emission and energy consumption after using task consolidation algo and VM migration.
4.Two Phase Consolidation Algorithm for Efficient Energy Consumption in Cloud Computing[4]	Single phase, Two phase task consolidation and two phase task consolidation	Using two phase consolidation algorithm reducing energy consumption and SLA violation	Manual virtual and physical machine assignment	Reduction of energy consumption by using two phase consolidation algorithm.

IV. PROBLEM STATEMENT AND OBJECTIVES

A. The problem statement

The problem statement posits the advancement of an Adaptive Energy-Optimized Consolidation Algorithm tailored for enhancing energy efficiency within cloud computing. This algorithm is designed to strategically allocate virtual machines (VMs) within data centers to reduicing energy usage while upholding users' service-level agreements (SLAs). The algorithm comprises two distinct phases: the initial placement of VMs and subsequent VM migration.

Presented is a methodical approach to tackle this issue statement: -

Conduct an extensive literature review: Analyze existing research on energy-efficient VM consolidation algorithms within the realm of cloud computing. Assess the strengths and weaknesses of various algorithms to identify gaps in the research landscape and determine potential contributions to the field.

Define clear objectives: Based on the problem statement, Define the goals of the proposed algorithm. These objectives may include minimizing energy consumption, maximizing resource utilization, reducing carbon emissions, and ensuring compliance with SLAs.

Develop the algorithm: Formulate the Two Phase Consolidation Algorithm in alignment with the defined objectives. The initial phase should focus on optimal VM placement to meet SLA requirements while minimizing energy usage. The subsequent phase should involve identifying underutilized servers and migrating VMs accordingly to further reduce energy consumption.

Implement the algorithm: Utilize a programming language such as Java, Python, or C++ to implement the Two Phase Consolidation Algorithm. Test the algorithm using either a cloud simulator or a real-world cloud environment to validate its functionality.

Evaluate algorithm performance: Assess the productivity of the Two Phase Consolidation Algorithm in terms of energy consumption, resource utilization, SLA adherence, and carbon 1 emissions. Conduct a comparative analysis of these findings with established algorithms to underscore the effectiveness and performance of the proposed methodology.

Disseminate findings: Document the research findings in a comprehensive research paper and seek publication in a reputable conference or journal. This will enable the distribution of your research among the wider academic audience and add to the ongoing discourse within the domain of green computing and cloud optimization.

B. The main objective

The primary aim of the Two Phase Consolidation Algorithm for The objective of improving energy efficiency in cloud computing involves diminishing the energy consumption of data 8 centers while ensuring the satisfaction of users' service-level agreements (SLAs). Specifically, the algorithm endeavours to: - Optimize the allocation of VMs among physical servers to minimize energy consumption, 6 while ensuring compliance with SLA demands. - Identify underutilized servers and transfer VMs from those servers to others, thereby further curbing energy consumption. - Improve resource utilization in data centers aim to reduce the occurrence of idle servers and, consequently, conserve energy. - Ensure that users' SLAs are met by allocating sufficient resources to each virtual machine (VM). - Reduce carbon emissions through the reduction of energy usage in data centers. In essence, the Two Phase Consolidation Algorithm aims to enhance the energy productivity of cloud computing systems, lower operational expenses, and contribute to the promotion of environmental sustainability.

V. SYSTEM ARCHITECTURE

The system architecture represents the organized arrangement of configurations that defines both the structure and functionality of a system. This depiction of architecture is structured to facilitate analysis of the system's structural characteristics. It delineates the constituents or aspects of system and provides a structure from which products can be derived and systems can be developed. These infrastructures are formulated to cooperate efficiently to implement the overarching framework.

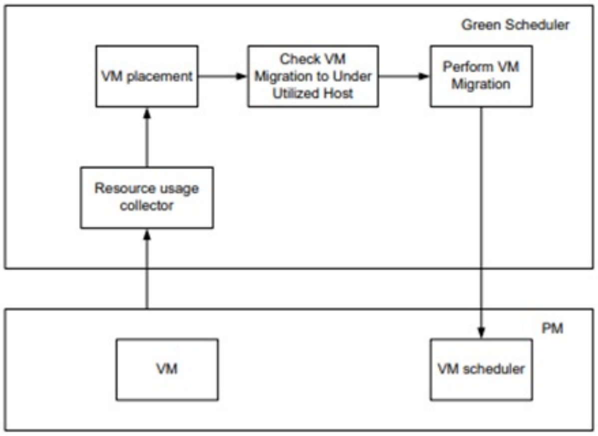

Figure1: Flow for assigning the Virtual Machines to Physical Machines.

VI. ALGORITHMIC APPOROACH

This study references two algorithms: one for task consolidation and another for job submission and scheduling. The algorithms utilized for reference are as follows:

A. Algorithm for Single Task Consolidation. Following this, an procedure is devised using insights from the reference algorithm mentioned earlier.

B. Two Phase Consolidation Algorithm. Prior to exploring the algorithmic approaches, it is imperative to grasp the metrics employed for calculating energy usage, resource utilization, and performance metrics.

The following metrics are considered:

a. Utilization Function: This metric evaluates the utilization of resources for a particular 3 task, considering both the processing duration and processor utilization. The utilization function, denoted as Ui at any given moment, is influenced by the quantity of tasks in operation (n) and their respective resource allocations (ui,j).

$$Ui = \sum_{J=1}^{n} u_{i,j}$$

b. Energy Consumption: The energy consumed by a resource ri at any given time is calculated using the parameters pmax and pmin, which represent energy consumption at peak load (100% utilization) and minimum power consumption in active mode (1% utilization), respectively.

$$E_i = (p_{max} - p_{min}) \times U_i + p_{min}$$

c. Cost Function: To compute the actual energy consumption of a task, the cost function is utilized, which subtractsthe minimum energy consumption (pmin). The task tj's value fig on resource ri is determined through parameters including the discrepancy between pmax and pmin (pΔ), the task utilization rate (uj), and the aggregate processing time of the task (T0, T1, and T2).

$$f_{i,j} = ((p\Delta \times u_j + p_{min}) \times T_0\Delta - \Delta(p\Delta \times u_j + p_{min}) \times T_1 + p\Delta \times u_j \times T_2\Delta$$

A. Single Task Consolidation Algorithm:

The task consolidation algorithm, also known as the server/workload consolidation algorithm, is designed to merge tasks while adhering to time constraints. The aim of this consolidation is to reduce energy usage while optimizing resource utilization. This involves assigning a set "T" consisting of "t" tasks (i.e., service requests or services) to a set "R" comprising "r" cloud resources.

Input: A tasks tj from set T and r cloud resources from set R

Output: matching of task and resource

1. Let $r^* = \varnothing$
2. **for** $\forall r_j \in R$ **do**
3. Compute the cost function value $f_{i,j}$ of t_j on r_i
4. **if** $f_{i,j} > f_{*j}$ **then**
5. Let $r^* = r_i$
6. Let $f_{*j} = f_{i,j}$
7. **end if**
8. **end for**
9. Assign t_j to r^*

B. Two Phase Consolidation Algorithm.

The Two Phase Consolidation Algorithm emerges as an advancement over the existing Single Threshold Consolidation approach, which, despite its advantages, is marred by drawbacks such as an increased number of VM migrations leading to SLA violations. This poses challenges as 1 excessive migrations waste CPU cycles and energy. To address this, the Two Phase Consolidation offers a superior solution, minimizing VM migrations and consequently reducing SLA violations, energy consumption, and CPU utilization. Further elaboration on the Two Phase Consolidation will be provided in subsequent chapters

The aim of this system is to decrease energy consumption in data centers for cloud computing through optimization of virtual machine scheduling, all while upholding high-quality service standards. Implemented using the CloudSim toolkit, the approach is compared with recent popular methods. The assessment outcomes confirm our attainment of both objectives lowering energy usage and maintaining service quality, achieved by minimizing the frequency of virtual machine migrations.

- Input: Task and Resources
- Output: Task and Resource matching.
- Advantage: very less CPU usage, resulting in less energy consumption.

***Steps*:**

1. Start.
2. Set the lower and upper threshold values after observing the behavior of the system and VMs.
3. Give tasks as input to the cloud system.
4. Check for the VMs in cloud and assign the VMs to the Jobs.
5. Assign the Physical Machines to VMs.
6. Check for the Over-Utilized VMs.
7. If VM's CPU usage is more than threshold value
    - Then migrate the load of over-utilized VM to under-utilized VM.
8. Check if there are still under-utilized hosts.
    - Then migrate the load of those VMs to the VMs which are operating in energy barricade.
9. Put all the empty Hosts to sleep mode.

VII . Results

- **Inserting Physical Machines and assigns MIPS**

In the depicted snapshot, physical machines are instantiated with distinct PM IDs and varying MIPS values. Following their creation, each physical machine makes a decision between two actions: either opting for no consolidation or pursuing consolidation.

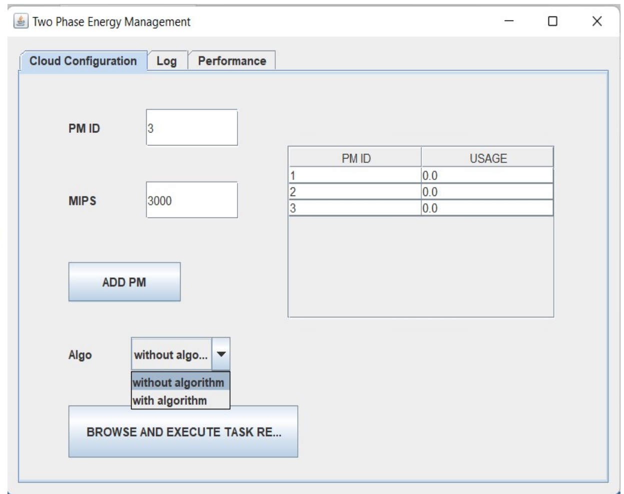

Figure2: Inserting physical machines and MIPS

- **Browse the file which is to be given as input load:**

Select the "Browse File" button and choose the load for the configured system. Various loads are available, each yielding different values based on the specific load selected.

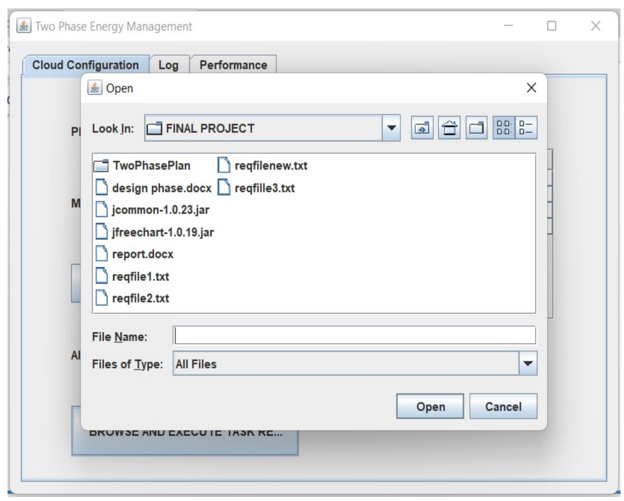

Figure3: Browse and select the file which is to be given as input load.

- **Checking the CPU Utilization:**

Upon selecting the load, the system initiates its operations. The following snapshot displays the observed CPU usage subsequent to the provision of the load.

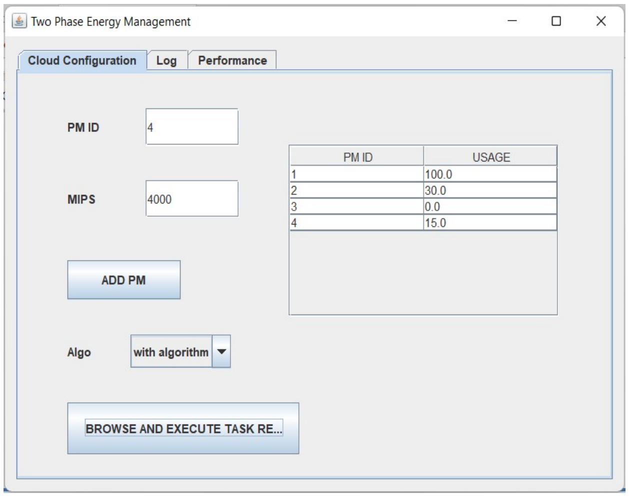

Figure4: Checking the CPU Utilization.

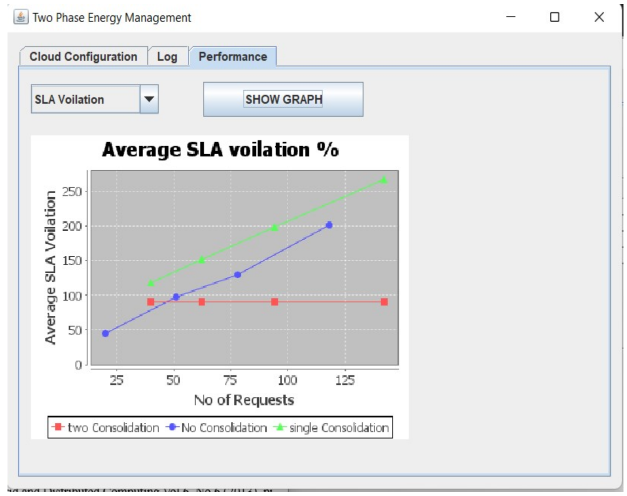

Figure5: Graph for number of SLA Violations.

- **Graph for the number of Migrations:**

The observation indicates that VM migrations do not occur when the no consolidation option is chosen, as this reflects the typical cloud operation without employing any algorithm. Conversely, in the case of the two-phase consolidation algorithm, a higher number of VM migrations are observed compared to the single threshold algorithm.

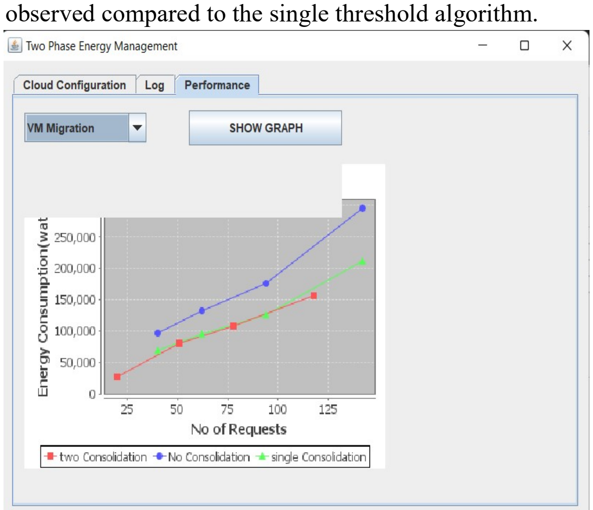

Figure4: Graph for number of Migrations.

- **Graph for number of SLA Violations:**

In the two-phase consolidation algorithm, SLA violations are effectively addressed, resulting in fewer instances of SLA violations compared to both the Single Threshold and No Consolidation options.

- **Graph for number of Energy Consumption:**

The observations regarding energy consumption by VMs during experiments conducted with various loads and methods reveal distinct patterns. Specifically, it is evident that energy consumption is higher in scenarios where no consolidation algorithm is employed within the cloud environment. Conversely, energy consumption decreases notably when utilizing the Single Threshold algorithm, and further decreases when employing the Two-Phase Consolidation algorithm.

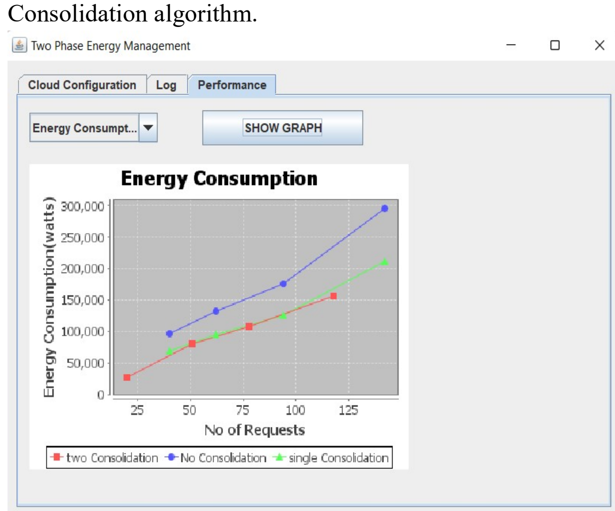

Figure6: Graph for number of Energy Consumption

VIII. Conclusion and Future Scope

The research conducted herein primarily tackles a common issue encountered in various scheduling algorithms, offering potential solutions that can serve as foundational improvements over existing methodologies. Through the experimentation conducted, it was observed that when combined with conventional migration methods and VM selection criteria, the two-phase consolidation method outperformed other algorithms in mitigating SLA violations, reducing the number of migrations, and demonstrating superior efficiency in CPU energy consumption.

The Two-Phase Consolidation algorithm method facilitates VM migrations aimed at optimizing overall parameters, notwithstanding user behaviour and potential SLA violations, occasionally leading to service starvation for extreme SLA violations among users with specific VM configurations. The focal point of this study is to endeavour to mitigate the impact of maximum SLA violations experienced by individual users by averaging the SLA violation values, while concurrently minimizing both VM migrations and energy consumption. Future research endeavours could explore methods to further reduce VM migrations within the Two-Phase Consolidation algorithm, thus achieving even more favourable outcomes.

REFERENCES

[1] Power management in cloud computing using green algorithm, IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM -2012) March 30, 31, 2012.

[2] A Study on Green Cloud Computing, International Journal of Grid and Distributed Computing Vol.6, No.6 (2013), pp.93-102.

[3] A. Jain, M. Mishra, S. Kumar Peddoju and N. Jain, (Eds.), "Energy Efficient Computing Green Cloud Computing", Proceedings of the International Conference of the Energy Efficient Technologies for Sustainability (ICEETS), (2013) April 10-122; Nagercoil.

[4] Abhinandan P. M., "Two Phase Consolidation Algorithm for Efficient Energy Consumption in Cloud Computing", International Journal of Computer Science Trends and Technology (IJCST) – Volume 6 Issue 6, Nov-Dec 2018.

[5] Anton Beloglazov and Rajkumar Buyya, "Energy Effcient Resource Management in Virtualized Cloud Data Centers," in 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, 2010.

[6] Anton Beloglazov and Rajkumar Buyya, "Adaptive Threshold Based Approach for Energy Effcient Consolidation of Virtual Machines in Cloud Data Centers," in ACM/IFIP/USENIX 11th International Middleware Conference, 2010.

[7] Anton Beloglazov, Jemal Abawajy, and Rajkumar Buyya, "Energy-Aware Resource Allocation Heuristics for Efficient Management of Data Centers for Cloud Computing," journal of Future Generation Computer Systems, vol. 27, no. 8, April 2011.

[8] Rodrigo N Calheiros, Rajiv Ranjan, Anton Beloglazov, César A. F De Rose, and Rajkumar Buyya, CloudSim: A Toolkit for Modeling and Simulation of Cloud Computing Environments and Evaluation of Resource Provisioning Algorithms. USA: Wiley Press, 2010

.

[9] SUN Microsystems, "Introduction to Cloud Computing Architecture," White Paper 2009.

[10] EMC 2008 Annual overview Releasing the power of information, http://www.emc.comJ digital_universe.

[11] R. Bianchini and R. Rajamony, "power and energy management for server systems," IEEE Computer, voI.37,no. ll,pp.68- 74,2004