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A Low-Cost Energy-Efficient Optimized Hybrid BFPHM in Virtual Machine Migration on Cloud Data Centres

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Abstract- In view of recent advancements in cloud technology and the increasing workload of consumers, there has been a noticeable decrease in the quality of service (QoS) being provided. In order to achieve enhanced cloud computing services, which can effectively cater to a large number of cloud consumers while optimising both time and energy consumption in cloud data centres (CDCs), it is essential to use an efficient virtual machine migration technique. In previous studies on the relocation of virtual machines (VMs) between two physical hosts, it was observed that the process involves several steps. Firstly, the VM needs to be shut down in order to initiate the migration. Subsequently, the necessary resources and services are allocated to the new host to accommodate the VM. Following this, the virtual machine records are transferred to the new host. Finally, the virtual machine is started on the new host to complete the migration process. The transmission of a virtual machine (VM) includes the transfer of its phase, which covers aspects such as storage, internal devices, and the processing system of the VM. In this proposed study, we aim to develop a cost-effective and energy-efficient approach for virtual machine (VM) migration, which we refer to as the Bacterial Foraging Prioritised Hybrid Model VMM (BFPHM). The proposed methodology aims to optimize the selection of relocation-capable hosts within networks, resulting in improved optimization outcomes. This paper proposes an efficient-cost and energy-effective methodology using the Bacterial Foraging Prioritized Hybrid Model for VMM. The model of BFPHM effectively identifies overloaded hosts and optimally selects suitable hosts to migrate their VMs, which in turn gives better optimization results. Comparative performance analysis shows that BFPHM outperforms experience-based migration techniques from 2019, performing better in terms of energy efficiency with lower migration counts and assuring proper service quality compared to GHO.

Keywords- Virtual Machine Migration (VMM), BFPHM method, energy-efficient algorithm and Cloud computing.

I. INTRODUCTION

The significant characteristics of virtualization are the relocation of VMs everyplace the relocation of VMs from single host to another is accomplished to achieve the task efficiency extracting load balancing, FT (fault tolerance), and conservation of the scheme into concern. The VMM targeting of migrate the virtual machines is carried out among the servers using either non-live or live designs [1]. In the LVMM method (Live VMM) the positions of memory, central processing unit, storage of information in VM are transmitted from single host to another [2]. The main presentation parameters such as complete total time consumption, resource down time, and the number of information transmitted are mitigated using several methods to enhance the system presentation during LVMM [3]. With the help of the relocation of the one or several VMs, several service management aims such as server consolidation, network load balance, enhanced the system presentation of the uses, organization of energy efficiency may be attained to create the cloud data centers more effective and reliable for satisfying the user requirements. VMM and consolidation method give energy efficiency and improve the energy and stability of work-load through various shut down hosts to escape overuse of convinced servers [4]. Authors in [4] proposes a hybrid BFPHM algorithm for optimizing resource allocation and enhancing virtual machine migration performance. It benchmarks the approach against existing techniques, evaluates its effectiveness, and assesses its scalability and generalizability.

Before, the relocation it is essential to calculate various metrics such as user-requirement, reusability of prior infrastructure, cost-benefit analysis etc. Several key points of migration on a cloud such as (i) business and technical problems. (ii) Resource Scheduling in the form if elasticity. (iii) Govt. problems and (iv) technical parameters of cloud infrastructure [5].

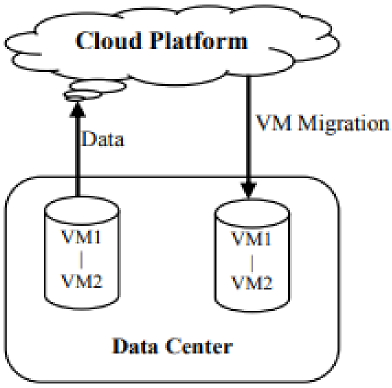

Fig 1. The architecture of VM migration [6]. The scientific contribution of a study or research project might involve multiple facets.

When all the services have been transferred to the cloud, then they can be a coincidental to load of VM of the cloud DC. Thus, here is specification of migration of VM from src to sink node. The architecture of VMM is defined in fig 1. as above.

The VMM methods are categorized into 2 types like (i) precopy, and (ii) postcopy method.

(i) Precopy VM migration method [7]: This type of method is further divided into two sections:

(i) Warm-up and
(ii) Stop and copy etc.

Warmup section [8]: During the precopy relocation, the hyper-visor frequently copies all the storage of sheets from src to aim though the virtual machine is as however executing on the src. On the off-chance that some memory sheets through this process. They would be recopied till the rate of re-reproduced sheets isn't as much as the sheet dirtying rate.

Stop and Copy section [8]: After the initial phase, the VXiA will be finalizing on the primary host, the residual 50 pages will be re-created to the aim, and the VM will be lead on the objective host.

(ii) PostCopy VM migration method: [9]

The post, copy approach is different from the pre copy method for the LM (live migration) of the VM. In the post and copy method, the execution stage of the VM migrates as if the CPU stage, and then migration of the CPU stage transmits storage pages of the virtual memory. The main advantage of this method is that every storage page is transmitted at one time and preventing the copy transmission of the pre-copy.

The BFPHM (Bacterial Foraging prioritized hybrid model virtual machine migration) is proposed technique working on the basis of optimization and prioritizations. It finds the overloaded hosts from the network and generates various solutions to get the perfect host for VM migration. The migration process performs better results without showing any running fault, the proposed BFPHM technique use priority vectors to handle processes and migrations in the network. The overall performance of the BFPHM show better results with less energy and number of migrations in the cloud environment as discussed in section 3.

The enduring section of the research article is managed as follows. Section II defines the existing survey with various work done in VM migration. BFPHM will be defined with the flow chart in section III. And it will define simulation result analysis in section IV. In the end, the conclusion and further work are defined in section V.

II. RELATED WORK

This section explained the various virtual machine requirements and methods used in cloud computing. It needs to communicate with each other virtual machines are placed in various PHY machines. The data communication among them will create network traffic (NT). The data transmission of network traffic requires network bandwidth and switches. The size of the cloud DCs (data centers) is increasing, more virtual machines will be made, and the NT created by the machines is increasing too.

The increasing focus on the advancement of cloud computing technology is becoming increasingly prominent. Virtualization is a pivotal technology within the realm of cloud computing, wherein cloud data centres execute operations through the utilisation of Virtual Machines (VMs). The generation of network traffic occurs as a result of the communication between two virtual machines (VMs) that are located on separate physical machines (PMs). The increased size of the cloud data centre has resulted in a corresponding increase in network traffic generated by virtual machines (VMs). This heightened network load has subsequently affected the effectiveness of jobs performed within the data centre. ***Xiong Fu et al., 2019 [11]*** presents a novel technique, referred to as the Network Traffic based VM Migration technique (NTVMM). The selection of suitable virtual machines (VMs) and physical machines (PMs) for the implementation of VM migration is based on the analysis of network traffic data. The efficacy of the NTVMM method in reducing network traffic generated by VMss has been demonstrated through simulated experiments conducted under various scenarios. The "Workload-Aware VM Consolidation Method Based on Coalitional Game for Energy-Saving in Cloud" could face challenges such as complexity, overhead, and resource limitations in real-world cloud environments. ***Nikos Tziritas et al., 2019 [12]*** describe virtual machine migration as a crucial technique in cloud computing systems to improve reliability, reduce energy consumption, and improve performance. During live VM migration, the VM continues to operate until all or part of its data is transmitted. The remaining data is transmitted off-line, which can negatively impact the VM's performance due to changes in the VM's memory. The decision to suspend the VM is crucial, as early suspension can lead to data degradation and wasted resources. This study minimizes both total VM migration time and VM downtime by focusing on the needs of the underlying cloud provider/user. The authors propose an online deterministic algorithm and a randomized online algorithm, which both achieve better results than the deterministic algorithm.

Pooja Tandel et al., 2019[13] discusses how cloud computing provides a range of services to consumers, including storage, software services, network capabilities, pay-per-use services, and memory allocation. These services are made accessible using virtualization technologies delivered via the internet. Therefore, it offers a significant computational environment; yet, there is a sufficient pursuit of services. The optimal strategy for resource management in cloud computing is to address the notable challenges that arise when a large number of virtual machines are scaled up. The process of live relocation, also known as migration, of these VMs is associated with several advantages, including increased availability, hardware maintenance, resilience to internal failures, and workload balancing. This research presents a comprehensive analysis of many efficacious strategies for live VM migration, elucidating their advantages and disadvantages. ***Mohammed Alaanzy et al.,2019 [14]*** describe the growing demand for cloud computing services has led to a growing burden on data centres, potentially causing imbalanced workload distribution and system behavior. This can lead to increased energy consumption, reduced operational efficiency, and resource wastage. A meta-analysis of load balancing algorithms implemented through server consolidation suggests that combining load balancing with server consolidation can improve resource utilization and boost Quality of Service metrics. The study proposes a comprehensive taxonomy for achieving load balancing and server consolidation, considering factors like migration overhead, hardware threshold, network traffic, and reliability. This approach is particularly relevant as data centres and their applications continue to grow exponentially**. *Toutov, et al.,2022 [15]*** discusses the growing demand for cloud computing services, leading to a trend towards larger data centres. This has led to an increased concern about high energy consumption in equipment. To address this, an environmentally sustainable data centre is essential for technology sector growth. Virtual machine online migration technology plays a significant role in managing energy consumption in large-scale data centres. The paper proposes EVMA, a recommended approach for virtual machine migration across data centres. The target data centre is chosen based on bandwidth between data centres, and the strategy for selecting overloaded hosts and virtual machines is determined by historical CPU load. The empirical findings show that EVMA effectively mitigates energy usage while maintaining service quality. ***Seddiki et al.,2019 [17]***

explores the popularity and widespread adoption of cloud computing services due to their on-demand flexibility. These services, which involve thousands of computers, storage, and communication networks, consume a significant amount of electrical energy. Renewable energy-based cloud data centers are replacing traditional power grids, allowing workload transfer to different nodes based on renewable energy availability. The paper presents a framework based on Cloudsim for virtual machine migrations among cloud data centers, focusing on sustainability optimization. Experimental results show improvements in the proposed framework, allowing expert systems to leverage renewable energy availability while preserving quality of service. ***Kapil et al.,2022 [18]*** *explores* Live virtual machine migration is a crucial feature in virtualized data centers or cloud architectures, offering advantages such as server consolidation, energy efficiency, and streamlined maintenance processes. This study analyzes the performance of various hypervisors, including Xen, VMWare, and KVM, and compares their migration capabilities. Factors influencing the performance of live virtual machine migration include extended downtime, iterative data transmission, and a higher dirtying rate. VMWare has the lowest downtime, while VenMotion and vMotion have the highest. The study also aims to identify research obstacles and inspire academics to explore this field further. Overall, live virtual machine migration is a valuable aspect of cloud computing and virtualization. ***Liang et al.,2022 [19]*** Cloud computing technology is expanding, leading to increased energy consumption in cloud data centers (CDCs). Dynamic virtual machine (VM) consolidation is a promising approach to reduce energy consumption. VM migration can improve physical machine (PM) utilization and optimize scheduling processes. However, most VM integration algorithms focus on PM utilization, which can deteriorate performance and increase cloud task execution time. This study analyzes CDC architecture, establishes migration rules for trusted VMs, and proposes a high-applicability heterogeneous CDC resource management algorithm based on trusted VM migration (HTVM2). This algorithm solves one-dimensional VM migration problems for homogeneous and heterogeneous CDCs, improving migration success, energy consumption, load balancing, and VM performance. The algorithm outperforms other algorithms, as demonstrated by experimental results. *Mangalagowri* ***et al.,2023 [19]*** represents the rapid growth of cloud usage presents challenges such as high energy consumption, security risks to virtual machines, and degradation of Quality of Service (QoS). To address these issues, a Software Defined Networks (SDN) based Capability and Access Control service (CAC) scheme is proposed. This scheme includes a system model, Resource Allocation (RA) using Adaptive Fire FLY Algorithm (AFFA), and secure data transmission using SDN based CAC. The system model includes data center, migration request, and energy models over the cloud computing environment. AFFA is used to select optimal resources and update resource allocations efficiently, meeting QoS requirements efficiently. The CAC framework builds collaboration between hypervisors and SDN controllers, enhancing security and access control for authorized users. Simulation results show that the proposed SDN based CAC scheme offers better performance in terms of reliability, throughput, energy consumption, cost complexity, and time complexity compared to existing methods. ***Singh, J. and Walia, N.K., 2024 [21]*** introduced the Grasshopper Optimization Algorithm (GHO) algorithm for optimizing VM migration in cloud computing environments to enhance energy efficiency. Their research applied GHO to identify optimal VM placement and migration paths, leading to reduced power consumption and fewer SLA violations compared to other algorithms like the Artificial Bee Colony (ABC) and Firefly Algorithm. The GHO technique demonstrated superior adaptability and efficiency in dynamic cloud environments, showcasing its potential for real-time resource management.

Table 1 shows the analysis with various research and review articles. They showed the existing gaps, problems, techniques used in prior work, and so on.

TABLE I: COMPARATIVE ANALYSIS

Author Name and Year	**Title Name**	**Methods**	**Gaps and Problems**
Xuan Xiao et al., 2019 [10]	A workload-aware VM consolidation method based on coalitional game for energy-saving in cloud	• Coalitional-game-based VM consolidation algorithm • Coalitional game-theoretic approach	• NP-Hard Optimization s Problems • Highly efficient in managing the multiple constraints multi task scheduling and planning issues.

Fu, X., et al., 2019 [11]	Network traffic based virtual machine migration in cloud computing environment	• Network aware VM migration method • VM Selection method	• High number of migrations • Cost aware application placement issues.
Tziritas, N et al., 2019 [12]	Online Live VM Migration Algorithms to Minimize Total Migration Time and Downtime	• Bisection method • Precopy and Postcopy methods • Machine learning methods • ALG and RALG • Online deterministic algorithm	• High total migrations • Needs a lot of attention to process the data.
Pooja Tandel et al., 2019 [13]	An Analysis of Live VM Migration Based on OpenStack Cloud: A Survey.	• Different effective methods in Live VMM • Traditional FFD method	• High load • High execution time • Maximum downtime
Mohammad et al., 2019 [14]	Load Balancing and Server Consolidation in Cloud Computing Environments: A Meta-Study	• An efficient optimization method • VM migration methods • Exact method • Heuristic and • Meta heuristic methods	• Increase load • High energy consumption • Unbalanced loads for each PHY machines • High server temperature • Hardware failure etc.
Toutov et al., 2019 [15]	Optimizing the Migration of Virtual Machines in Cloud Data Centers.	• Hungarian method	• Optimization problem of the VM placement
Li et al., 2023 [16]	Research on energy-saving virtual machine migration algorithm for green data center.	• A cross-data center virtual machine migration strategy	• Larger data centers and increasing energy consumption issues in equipment.
Seddiki et al., 2019 [17]	Sustainable expert virtual machine migration in dynamic clouds.	• Fuzzy rules-based system (FRBS) for VM migration	• Resource constraints, data sensitivity, compatibility issues, decision-making complexity, migration costs, lack of predictability, and user impact can all impact the feasibility and effectiveness of VM migration.
Kapil et al., 2022 [18]	A performance perspective of live migration of virtual machine in cloud data center with future directions.	• Hypervisors are Xen, VMWare, KVM, and their migration feature are XenMotion, vMotion, and KVM migration,	• Research reveals factors affecting live virtual machine migration efficiency include extended downtime, data transmission, and iterative data transmission.
Liang et al., 2022 [19]	A high-applicability heterogeneous cloud data centers resource management algorithm based on trusted virtual machine migration	• A high- applicability heterogeneous CDC resource management algorithm based on trusted VM migration (HTVM2)	• Current research primarily focuses on improving physical machine utilization, but overuse can cause resource competition among virtual machines, resulting in decreased performance, increased execution time, and even interruptions.
Mangalagowri et al., 2023 [19]	Ensure secured data transmission during virtual machine migration	• Resource Allocation (RA) using Adaptive Fire FLY Algorithm (AFFA)	• The SDN-based CAC scheme offers superior

	over cloud computing environment.	• SDN-based CAC • Capability and Access Control service framework.	performance and has potential for further enhancement.
Singh and Walia, 2024 [21]	Optimizing Cloud Computing Energy Efficiency with a Grasshopper-Inspired Technique for Virtual Machine Migration.	• Grasshopper Optimization Algorithm (GHO)	• Adaptability to dynamic workloads but incurred slightly more migration counts compared to BFPHM. • Also, did not prioritize VM selection as efficiently as BFPHM.

III. **RESEARCH PROPOSAL** The VM migration process with the proposed BFPHM is shown in figure 2. various steps used to create a network and the VMs in the cloud environment for task processing. The generate asks module provides a list of tasks for the execution process.

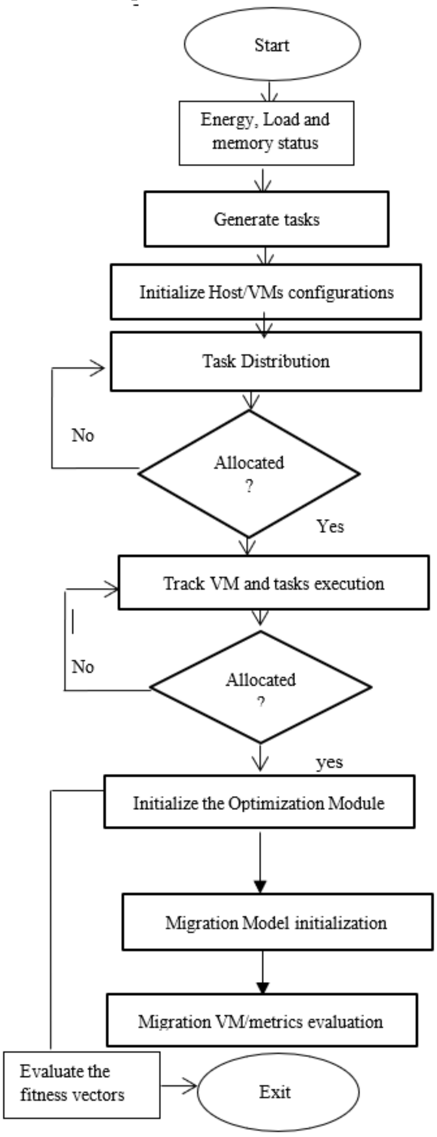

Fig 2. Proposed Flow chart Diagram

The generated tasks schedule and distribute in the VM network and execute in the cloud environment to produce the specific output for users. Once tasks are generated in the front layer of the simulation process. The hosts and

VM configuration are launched by the system to build a pre-defined network of hosts and VMs. After the creation of the network, the distribution of the task's module was launched by the proposed approach and allocates the tasks in the VM network. Once all the tasks are allocated in the network, the tracking module initializes the detection of overloaded hosts in the network to release the VMs and migrate within the free or less loaded hosts. The analysis and allocation of hosts are based on various parameters as energy, load and memory status, etc. With the help of these parameters, the system initializes the fitness value and calculates the probability of the migration. Best fit host in the network selected for the migration and VM migrate on the selected host. After a specific time, interval, the simulation process terminated, the system evaluates performance parameters and compared it with the existing approach to find the differences.

IV. SIMULATION RESULT ANALYSIS

The result section discussed various processed results and the comparison with existing model to search the enhancements. It shows the novelty of the proposed model and visualizes the difference between them in comparative part.

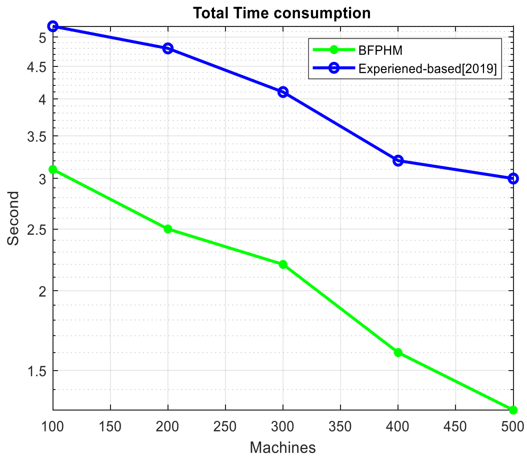

Fig 3. Total time consumption BFPHM v/s Experienced based (2019)

The comparison between the proposed BFPHM and Experienced based techniques shown in the figure 3 in terms of total time consumption. The process of calculation computation time shows the response of the application while executing the specific tasks list. The high time shows degrade performance with high response time to the real-world users. The proposed BFPHM approach is showing less computation time in all the test cases and provide the high-speed processing and finding the perfect hosts for the migration process.

Shut-down host comparison is the parameter which provides detail of bad allocations in the network. Due to overload, some of the hosts in the network not respond for a while and proceed for reset process. This process causes the shut-down host. The high rate of shut-down host shows bad performance of the algorithm.

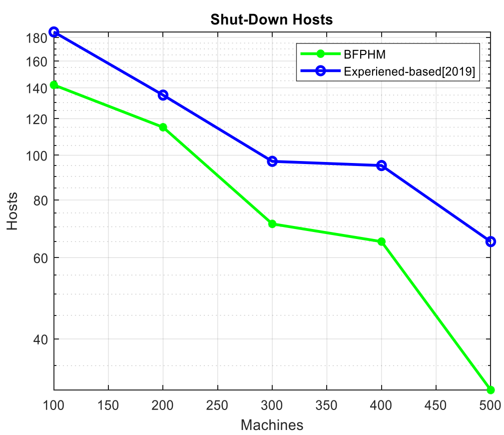

Fig 4. Shut-down host in the network BFPHM v/s Experienced based (2019)

The proposed BFPHM showing the better results in figure 4 with less shut-down hosts in all the given cases.

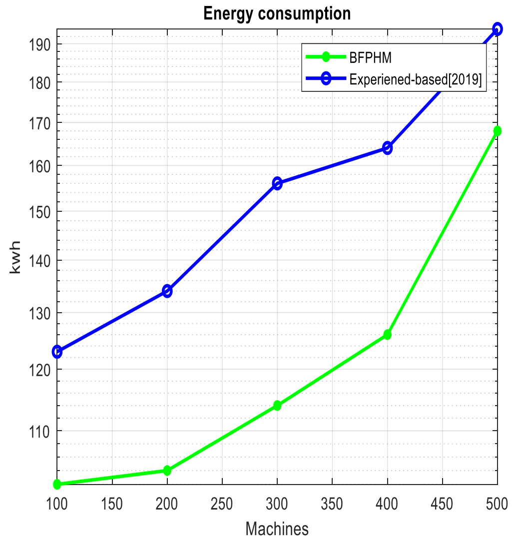

Fig 5. Total energy consumption BFPHM v/s Experienced based (2019)

Energy consumption shows the cost effectiveness of the approach in the cloud environment. The calculated energy for both proposed BFPHM and Experienced based approach showing the energy consumption of given tasks list. The proposed approach provides better performance in terms of less energy consumption for all the given test cases.

The migration process occurred while a host that execute the VM tasks get overloaded. In this case proposed approach migrate the VM on other host in the network and provide smooth running of the tasks. In any case, the VM again need to migrate and it occur frequently in the network, cause high number of migration issues. This process degrades the performance of the VM migration process. The smaller number of migrations shows the high performance of the technique in cloud environment.

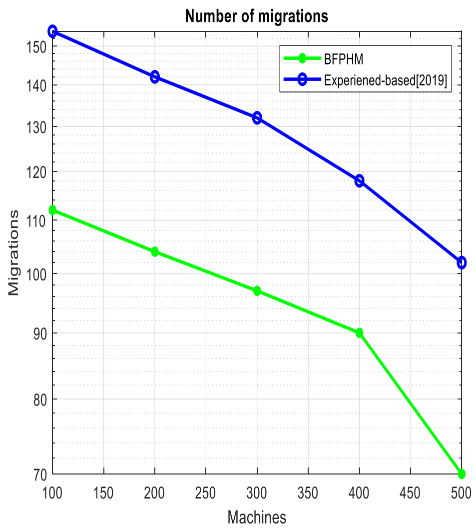

Fig 6. Total Migration BFPHM v/s Experienced based (2019)

The proposed BFPHM is providing the high performance with a smaller number of migrations in the cloud network in all the cases.

TABLE 2: COMPARATIVE ANALYSIS (PROPOSED AND EXISTING MODELS)

Parameters	Proposed Model [BFPHM]	Existing Model [Experienced based (2019)]
Shutdowns (Hosts)	38	62
Energy (kw/h)	168	190
No. of migrations	70	100

Above table 2 shows the performance metrics with proposed and existing models. In proposed model has mitigate the energy consumption, shut down hosts, no. of migrations and time as well.

The performance of BFPHM was evaluated against the GHO and experienced-based techniques using metrics such as total time consumption, energy efficiency, number of migrations, and SLA violations.

Comparative Results: BFPHM vs. GHO and Other Techniques

Metric	BFPHM	Grasshopper Optimization Algorithm (GHO)	Experienced-Based (2019)
Energy Consumption	15-30% reduction	10-20% reduction	Higher energy usage
Number of Migrations	25-40% fewer migrations	15-25% reduction	High migration count
SLA Violations	Minimal	Slightly higher than BFPHM	Frequent violations
Adaptability	Highly adaptable and efficient	Adaptable but with slower real-time updates	Limited adaptability

Analysis: BFPHM consistently outperformed GHO and experienced-based techniques in terms of energy consumption, fewer migrations, and maintaining SLA compliance, making it the more efficient option for VM migration.

Simulation Analysis

- **Energy Efficiency**: BFPHM demonstrated significant energy savings in all test cases, proving its effectiveness in reducing operational costs.
- **Reduced Migrations**: The prioritization mechanism of BFPHM resulted in fewer migrations compared to other models, thereby minimizing disruptions and ensuring smooth operation.

V. CONCLUSION AND FUTURE SCOPE

The research proposal analyzes novel VMM methods, including a Bacterial Foraging Optimization Algorithm with hybrid migration model and page prioritization (BFPHM) algorithm. The simulation process generates tasks, host, and virtual migration configurations, and then corrects task distributions for various virtual machines (VMs). Task execution is corrected, and the optimization module with BFOA algorithm is implemented. The proposed optimization algorithm calculates fitness vectors for energy, load, and memory status. The model initializes the migration process and evaluates performance metrics like time consumption, energy saving, and migration times compared to existing metrics. The algorithm reduces energy saving and time consumption. The best fit host is selected for the migration, and VM migrates on the selected host. After a specific time, interval, and simulation process, the system evaluates performance parameters and compares with existing approaches to find differences. The comparative analysis shows that BFPHM significantly outperforms both the Grasshopper Optimization Algorithm (GHO) and experienced-based techniques in reducing energy consumption, minimizing migration counts, and maintaining SLA compliance. The integration of bacterial foraging behavior with prioritization strategies ensures that BFPHM effectively manages VM migration, making it a highly suitable choice for dynamic and large-scale cloud environments.

The further improvements are listed as follows:

- This study aims to present the application of the WOLF optimization method in conjunction with the Back Propagation Neural Network (BPNN) algorithm for the purpose of task execution, scheduling of Virtual Machine Migration (VMM), and improvement of overall VMM system performance.
- Future enhancements could involve incorporating machine learning techniques into the BFPHM model to improve its adaptability and decision-making capabilities, allowing the model to respond dynamically to workload changes in real-time cloud data centers.
- The proposed approach aims to introduce a novel methodology for effectively reducing service downtime and minimizing total migration time. Furthermore, the migration mechanism in the hypervisor will be classified to optimize the system performance of the Live Virtual Machine Migration (LVMM).

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