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Research Article

# Hybrid Spotted Hyena based Load Balancing algorithm (HSHLB)

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**ABSTRACT**

In this article, we probe into the middle of our suggested dynamic burden distribution mechanism. We name it Hybrid Spotted Hyena based Load Balancing algorithm (HSHLB). To begin with, the current literature provides an overview of the Spotted Hyena Optimization Algorithm (SHOA) and its basic behaviors that include migration, and attacking. Next, we unveil what is referred to as Load Balancing Algorithm (LB), and explain its fundamental concepts at the same time as we reemphasize various special features. Thirdly, realizing that both SHOA and LB methods have their comparative advantages and disadvantages within our system, engagement in a hybridization process between SHOA and LB yields reputation for a more powerful HSHLB. Fourthly I will demonstrate how these three algorithms are applied jointly, and how best their beneficial qualities are taken by HSHLB without bringing about their disadvantageous attributes. While reading this section, the reader will be able to educates himself on how the HSHLB functions, which will enable him understand all the processes that are involved in this program among other parameters that are necessary for implementation hence simplicity shall be dealt through the use of pseudocode or flowcharts meant to depict the actual process of the implementation of HSHLB. To sum up to this stage of the work Section 3 introduced a theoretical basis for the application of HSHLB in an attempt to achieve the goal of dynamic load balancing to pave way to the remaining parts of the work which presents revised implementation strategies, results, and analysis. When comparing different aspects for example SHOA and LB; it prove beyond doubt that HSHLB could be an answer to many sided challenges resulting from load balancing within the cloud computing since resource provision can be optimally enhanced by strengths registering to these methods and more importantly improving on service quality(QoS). Resources appear to be likely to shift considerably in the future to big data oriented processes and techniques designed to help unlock the potential of Big Data. In this paper, we focus on the essence of the load balancing which is known as ,Hybrid Spotted Hyena based Load Balancing algorithm (HSHLB). First, we state general information about the Spotted Hyena Optimization Algorithm (SHOA) and the basic types of behaviors which it encompasses: the migration and attacking behaviours. We then proceed to the presentation of the Load Balancing Algorithm (LB) and underscore the definition of some of the algorithm's fundamentals specifically. Realizing the effectiveness and limitations of both SHOA and LB, we are ready to start discovering how to combine these two powerful tools and obtain an exquisite HSHLB. We explain how HSHLB algorithm integrates these two and specifically how it leverages on the strengths of both SDA and HMM while avoiding their weaknesses. This hybridization is pivotal to the overarching goal of achieving dynamic load balancing within cloud computing environments. As we progress through this section, we provide invaluable insights into the inner workings of HSHLB, offering readers a comprehensive understanding of its algorithmic steps, parameters, and intricacies. For clarity and enhanced comprehension, we incorporate pseudocode or flowcharts to illustrate the practical implementation of HSHLB.In sum, Section 3 lays the foundation for the practical application of HSHLB in achieving dynamic load balancing, setting the stage for subsequent sections where we delve into implementation details, results, and analysis. HSHLB emerges as a promising solution to the multifaceted challenges of load balancing in cloud computing, leveraging the unique strengths of SHOA and LB to optimize resource allocation and enhance Quality of Service (QoS). It looks like the future of allocating resources will be more data-driven to use Big Data power.

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## 1. INTRODUCTION

Within the ever-changing world of cloud computing, two major problems in the field are how to allocate resources efficiently and optimize quality service(QoS). In clouds, it is important that loads should be balanced dynamically so as to ensure cost-effectiveness through proper utilization of resources as well as provision of uniform high quality services over time. I want to focus on an organizational management tool which is more powerful and was designed to fulfill such a role. A new concept called dynamic load balancing, The HSHLB – where dynamic is a combination of change and perplexity; when using the identified two powerful optimization strategies, namely: Spotted Hyena Optimization Algorithm (SHOA) and Load Balancing Algorithm (LB), it is possible to come up with the new method of dynamic load balancing. It will explain the functions of HSHLB, Principle behinDS the above ones and more, with general steps involved during computations made according to the above conditions that leads to the successful completion of given tasks, among others, such as etcetera. . individual components of each one will be examined and demonstrated their strengths or weaknesses before they are integrated to form a single system design methodology. With these words said it can be concluded that this method aids effectively in solving task scheduling problems, when compare to some algorithms used earlier for the same that were having less efficiency of SHOA or LB algorithms, hence the hybridization of both algorithms that presents more efficiency than the previous practice up to now but there is still more scope of study on some areas.

Unlike the previous sections, this section that poses the main problem of this research aims at focusing on cloud environments in as much as how they could be optimally set to do dynamic load balancing. The following are the different aspects that make up this multi-faceted problem: (1)Resource Allocation and Utilization — In a cloud setting, User Tasks are hosted on the PMs, such that all Virtual Machines travel through them; allocating four core computational resources such as these in a way that will ensure that they are used to their maximum extent is one of the various challenges. This has been a big challenge in our field in that it is always difficult to distribute all the workloads within the PMs and VMs on the basis of the available capacity without averaging on other equipments. (2) Quality of Service (QoS): Customers leverage cloud services and in turn expect quality solutions that are defined by attributes such as minimum time taken to perform tasks or makespan, optimal cost and responsiveness. It is essential to be able to allocate tasks onto suitable resources without threatening desired QoS levels based on current levels of resource availability. Efficiency and Cost-Effectiveness: (3) Energy saving and cost optimization is another goal where cloud service providers constantly try to work efficiently and concurrently never feel they have done enough because for both goals there is always more that can be achieved in this aspect especially in the areas of efficient workload balancing between virtual machines which would help in cutting down on power and costs in industries where it is required. Stable VM Load — It is important for every organization setting up its own data center facility where many server racks would be installed at once then connect them all through one network switch thereby making sure that there will always be enough bandwidth space available for each rack taking into consideration varying loads across different times which could lead into bottlenecks being created anywhere along this network hence affecting overall performance adversely during peak hours mainly when some servers may have less work than others due to uneven distribution caused either by wrong configurations made during initial setups or failure implement proper load balancing mechanisms thereafter as required under prevailing conditions at any given point in time even though such scenarios might sometimes occur unexpectedly due unforeseen circumstances beyond human control altogether but still need continuous monitoring throughout working days unless specified otherwise by management itself only then should we consider shutting down certain equipment temporarily until such situations are resolved completely thus ensuring maximum utilization under all possible circumstances without fail whatsoever thereby guaranteeing uninterrupted services round clock everyday forever in eternity always and forevermore. (4) QoS Parameter Normalization: Such metrics like makespan, cost, and response time are different themselves not only by units of measure but the scales also; so to make a sensible comparison for the purpose of fair load balance it is necessary to operate over the metric values in some way to put all their values to the same scale at a given point in time with regard to the same resources.

Thus, it can be said that the present challenges are – What it takes to propose a unique solution that will effectively meet the demands related to dynamic load balancing for cloud environments? For such a system, what we would like to offer is a Hybrid Spotted Hyena based Load Balancing algorithm abbreviated as HSHLB. The primary objective of the paper is to present the design and implement details of HSHLB that integrate features of both SHOA and LB whenever necessary during their processing cycles to enhance the performance of algorithms in comparison to those used previously, which failed to adequately address factors of this nature and complexity across related system architectures and their lifetimes under changing workloads sometimes detected only occasionally over long periods rather than as steady pressures leading to optimal balance of demands on the managed effectively under prevailing conditions and By presenting a solution to these critical challenges.

## 2. QUALITY OF SERVICE (QoS) PARAMETERS

### 2.1 Makespan

Importance: Makespan is also another performance metric that speaks to the average time the tasks in cloud compute take to be done. This is considered as the most important factor in cloud computing since it guarantees that all user who keeps waiting for their jobs to be done fast would work efficiently. Relevance: Cutting down the makespan has been considered as one of the most important goals towards enhancing QoS in any cloud milieu. Presently, everyone wants everything fast, reactive, and effective too; they demand things to be done Optimally this has to be achieved at all costs, to fit these criteria. This implies that an effective load balancing algorithm which has been designed in such a way that it can actually minimize on makespan, will in the long run enhance the quality of the services delivered from clouds to the end users hence acknowledging providers competitiveness in the market also. Therefore, this paper aims at identifying ways on how we can minimize makespans through efficient load balancing However, traditional methods in load balancing can not go a long way thus need for better ingenious ways of load balancing such as proposing Hybrid Spotted Hyena based Load Balancing (HSHLB). This kind of technology could alter everything that is associated with resource management in cloud systems from this point forward since it has the capability to single-handedly transform the nature of organizational dynamics with regards to task completion. . HSHLB also /HSHLB also/ aims at improved overall user experience through optimal makespans consequently acting as a stimulus to towards the improvement of technology used in delivering services through clouds.

### 2.2 Resource Utilization

Importance: Resource utilization indicates the extent to which some resources such as Virtual Machines in a cloud computing environment or configuration are utilized during accomplishment of a particular task. In case, more resource consumptions means more tasks are being done at once ; the VM productive capacity is optimally utilized thus the efficiency levels step up as well. Relevance: As much as cloud service providers would want their business models to be cost efficient none can afford the wastage let alone where power conservation should be taken as the second to the few other sustainability concerns that may be worthwhile when talking of the environment like efficient utilization techniques that can be applied to the loaded Vms in such a way that any specific Vm is not overworking it self while the others are idle or vice-versa. Nevertheless, this can only be achieved if we have maximized resource usage for example with the HSHLB that was previously put forward with the Hybrid Spotted Hyena based Load Balancing. For this therefore to be actualized therefore it then becomes necessary that the tasks have to be evenly spread across all currently active virtual machines so that each is able to employ its resources to the maximum of its capacity to do so unlike where some where incongruously left idle or unused at all. . HSHLB operates in a manner that allocates tasks evenly across various VMs thereby enabling providers to achieve improved levels of operating efficiency, which, in turn, can reduce costs on energy and other logistical expenses in the operational framework of the entire system. This may have the potential to transform management dynamics related to cloud computing resources hence helping to bolster growth in this area.

### 2.3 Costs

Importance: Costs, in this respect are similar to fees; these are user charges for a product or service in the cloud computing network in proportion to their utilization of such elements as memory, Virtual Machines (VMs), processes or bandwidths among others. It is crucial in understanding and managing the cost that emanates both from the clients and the service providers. From the former’s standpoint: it is the ability to achieve a balance between an anticipated feature-set from any specific package tamed by what one is willing or able to shoulder From the latter’s perspective: cost management is the vital ingredient towards making businesses profitable against the backdrop of offering the Cloud Computing industry competitive prices. Relevance: It is impossible to overemphasize the importance of management and the aspect of cost control in any environment because people in charge cannot know where costs are probably going astray to be able to predict trends so that changes can be made at the right time but above everything; People want things done cheaply and without compromising quality.

In the case of HSHLB, the primary objective is to provide load and work distribution within the minimum cost attainable to users and also within reasonable and attainable parameters to ensure viable and effective operational capacity and profitability for providers in the cloud environment. If applied to the development of cloud systems, HSHLB, which integrates SHOA with Load Balancing Algorithm (LB), has the potential for enhancing the development of cost efficient and user centric solutions. Therefore, it may be argued that cost management is a very important factor in cloud computing environments today. In as much as customers expect high quality, suppliers have also to work very hard to make sales and earn revenues for their businesses hence making it another key factor that shapes this industry. This balance can be attained with the help of HSHLB algorithm which has capacities to solve such problems and due to which the cloud computing becomes affordable for both the supplier as well as the customers.

### 2.4 Response Time:

Significance: In cloud computing, response time is an important figure that indicates how the speed a system is able to handle the request of users. Small response times are important for such applications or services where user is constantly waiting for the application to respond and hence, directly impacts the user satisfaction. Relevance: Perhaps in today's world especially due to the advancement of web 2 technologies and other online tools. 0 applications ; The world has become a hub of dependents on some forms of services offered by cloud service providers with clouds that include data processing platforms such as the Google docs to real time collaborative software such as the office 365 and many more . Thus expectations of seamless interaction with the hosted environments of these applications must be met by all users who always deal with these service providers by reflecting speeds as possible. Hence, one is compelled to think that it's vital to work for a shorter response time to offer good customer experience whereby much delay leads to disappointment hence reduced productivity and this leads to losses of customers and the complete collapse of the business due to poor performance ascribed to the provider who fails to meet required demand yet its reputation will be damaged for avery long time due to other challenges incurred in this line as well. . Therefore, to contribute to the achievement of this objective effectively, it is suggested to develop hybrid spotted hyena based load balancing algorithm (HSHLB). It does so through partitioning of tasks such that the time between the two tasks is minimized, so that different tasks are executed on different machines. The required enhancements of the HSHLB algorithm amid tackling different assignments in cloud computing environments include the expecting to enhance the response time among other factors.

### 2.5 Normalization of QoS Parameters:

This means that a Cloud services or load balancing strategies can only be analyzed thoroughly if Quality of Service (QoS) parameters are scaled to a comparable measure. This step is very important since QoS parameters have different units and scales whereby if you try to compare them directly, it will be next to impossible and in the process, you end up with wrong conclusions or decisions especially when it comes to choosing the best suited provider for your needs for instance, based on these figures alone without also factoring in other aspects such as the price. . About this process as teachers we fully understand how important it is mainly because most of the time people purely do not comprehend what exactly is meant by any parameter let alone the ones that are measured in disparate indexes; such as the latency and bandwidth for instance that would require clarification in terms of certain context with regard to which they will be utilized and so on.

For instance, tables aggregating different QoS parameters normalize these parameters to typical values often in the scale of zero to one. The rationale for this process is to prevent elaborate dominance of assessing cloud's distinct performance characteristics by employing a single quality of service metric. Without the normalization step, it will be difficult to provide a measure of comparison for the different quantities such as makespan, cost or response time because they may have different numerical and dimensional values that are irrelevant in terms of a reference point to the other values of the different quantities. In doing so, cloud providers together with researchers will have a means of evaluating an all-inclusive as well accurate one where the opportunity to show what could be done better are distinguished by one thing against another in terms of these among others like when evaluating load balancing algorithms such as HSHLB, in the sense that many performance indicators are considered at once. Normalisation prevent bias in rating of HSHLB whether or any other type of load balancing strategy due to the scales inherent in some QoS parameters. This allows us to offer our suggestions as lecturers based on rational reasoning derived from reasonable assessments made about the effectiveness of such algorithms across various user requirements, and not merely in one environment used at teaching institutes like ours that work with many levels of student technical literacy regarding this subject matter area in general, based on what we now believe may occur if all were satisfactory.

## 3. THE FITNESS FUNCTION AS A MEASURE OF LOAD BALANCING EFFECTIVENESS

The fitness function involves costs and QoS metrics such as response times and makespan to provide an impact summary of the load balancing strategy. By so doing cloud administrators and providers are able to:By so doing cloud administrators and providers are able to:

- Proactively define and prioritize the distinction between multiple approaches resting upon considerations of the user-centric metrics that are highly relevant to the delivery of cloud service – this can be met through the application of fitness functions.
- Determine whether load balancer has met pre-specified performance goals – this function can be used to set a baseline by which improvements resulting from load balancing will be determined based on reduction of costs, endurance of response time or boost in utilization of resources among others.
- Maintain resource utilization in a manner that will always seek to increase constantly the utility of the resource by the users as well as enhance resource productivity over time. This is an implication to the fact that through data driven decision making supplemented by such a kind of an evaluation criterion, more enhanced load balancing mechanisms can be achieved; and hence efficient, effective and responsive clouds services on the end part.

Fitness function facilitates progressive transition from broadly calculated rules or heuristics to data-driven schemes for load balancing of cloud environments. As a result, it would also be possible to derive more complex algorithms out of it like the HSHLB algorithm which could capitalize on the increased resource allocation possibilities as well as the intended better QoS delivery to users in the cloud. It is only useful to make better choices regarding strategies that providers have to employ after they have been equipped with information that comes from a supply through the fitness function. Therefore they will keep on working on them until they attain perfection hence customers are satisfied all the time because there cannot be any other way in which service failure will occur again after being made reliable through various ways including this one where providers ensure that they have made it impossible to fail in another way apart from power supply failure only but still even in this case people need to have computing equipment connected somewhere within range otherwise life becomes very tough and especially today tomorrow and More less.

## 4. RELATED WORKS

The work by Li et al. (2022) [13] has investigated DAMNIPFSP – which stands for the distributed assembly mixed no-idle permutation flow-shop scheduling problem – with a special focus on total lateness criterion. He and Li constructed the mixed-integer linear programming model and proposed RIG which includes the new destruction and reconstruction strategies as well as local search references. Overseas studies portray that the value of algorithms regarding solution quality of RIG algorithm and computational time is acceptable making it as one of the most sophisticated algorithm of DAMNIPFSP with total tardiness criterion.

This research demonstrates how swarm intelligence may be used to solve complicated scheduling problems within manufacturing systems. As educators ourselves, we can see these methods being applied or further developed in cloud computing where dynamic resource allocation and performance metric optimization pose significant challenges.

The knowledge gained from FSSP studies like these could also give rise to new types of load balancing algorithms for example HSHLB (Hybrid Spotted Hyena based Load Balancing) which aims at addressing various aspects of resource management in cloud computing environments. Mahmud et al., (2022) [14] proposed bi-objective integrated supply chain scheduling model along with two meta-heuristic algorithms based on multi-objective particle swarm optimization (MOPSO) for solving strongly NP-hard flexible job shop problem.

Gümüşçü et al., (2022) [15] compared different local search strategies within chaotic hybrid firefly particle swarm optimization algorithm in flow-shop scheduling considering their impact on results quality.

Vali et al., (2022) [16] introduced patient flow optimization approach that should minimize total carbon footprint while solving flexible job shop scheduling problem. Chaotic Salp Swarm Algorithm Enhanced with Opposition-based Learning and Sine Cosine (CSSAOS), a metaheuristic optimization algorithm specially designed to handle NP-hard problems was used by them.

We have been following the progress in optimization algorithms for Permutation Flow-Shop Scheduling Problems (PFSPs) as researchers. I would like to mention some of the recent achievements in this field.

Hayat et al. (2023) [17] combined Particle Swarm Optimization (PSO) with Variable Neighborhood Search (VNS) and Simulated Annealing (SA) methods to improve PFSP solving abilities. The new hybrid algorithm, HPSO, was compared against other 120 different Taillard instances demonstrating robustness and enhanced makespan optimization over other hybrid metaheuristics applied so far.

Sun et al., 2023 [18], improved genetic algorithm by using tabu search in production scheduling technology for knitting workshops. The research was conducted at Zhejiang Sci-Tech University Key Laboratory of Modern Textile Machinery & Technology of Zhejiang Province, School of Automation, Zhejiang Institute of Mechanical & Electrical Engineering with aim to increase production efficiency and lower costs associated with knitting operations. Proposed IGA showed faster convergence than traditional genetic algorithms as well as better search capabilities thus offering insights into intelligent development within knitting production area.

In addition to that, our survey revealed few state-of-the-art optimization algorithms for FSSP such as GA-SHOA, WD [19], GA [19], IHSA [19], PSO [19], CLS-BFO [20], AGGA [20] or SSO [20]. These have been chosen as benchmarks during testing phase where they were compared against proposed hybrid solution presented here.

The GA-SHOA is a new kind of crossover algorithm which combines the exploration ability of SHOA (spotted hyena optimization algorithm) with the exploitation ability of GA (genetic algorithm) to search the solution space effectively. CLS-BFO is a compound algorithm that applies cuckoo search (CS) and the Broyden-Fletcher-Goldfarb-Shanno (BFGS) method for solving FSSP. Other algorithms like WD, GA, IHSA, PSO, AGGA and SSO have also shown great promise in addressing FSSP problems. We look forward to further breakthroughs in flow-shop scheduling problem optimization methods as they hold potential for enhancing productivity, efficiency and cost-effectiveness across different industries and manufacturing settings. These findings can be used as foundations for load balancing algorithm innovation, such as Hybrid

Spotted Hyena based Load Balancing Algorithm(HSHLB), which seeks to handle dynamic resource allocation challenges in cloud computing environments.

## 5. USING BIG DATA TO MAKE RESOURCE ALLOCATION MORE EFFICIENT IN OPTIMIZATION

Using large, difficult sets of information to guide and optimize decisions about the use of resources has become a major competitive advantage. The world today is driven by data, with businesses having to make sense of huge amounts of it from various sources such as transaction records, social media, sensors among others. This is what people commonly refer to as big data which poses challenges as well as opportunities. One opportunity that stands out involves using advanced analytics for determining how best limited facilities can be distributed through optimization methods. Some of them include; healthcare; transport; production; telecommunication industry and banks but to mention only a few of the other sectors where competent management of resources is significant. Heretofore, the allocation of resources involved the use of some rules-of-thumb based on prior data and/or the knowledge and standards of practitioners. However, such a scenario has been vastly altered by the use of tools made available due to the impact of big data that makes developers make them more data driven and at the same time optimized. In its most basic definition, Big Data is the unit of data that are too large for common mathematical software tools to process adequately. They may also consist of structured or unstructured, or even both of these types of information in any forms that may be sourced both from semi-structured sources as well. They might experience an issue with storage due to the large size of the data set, while speed and variety are also an issue when it comes to analysis; however, if wielded effectively, it will offer valuable insights that can be useful in determining how resources should be allocated to available options. Optimization techniques have been useful in these processes as they combine the use of mathematical models and computer algorithms in making the best choices out of the various possibilities that are available. Some of the techniques include categories that include linear programming, integer programming, dynamic programming and meta heuristic including genetic algorithms and the simulated annealing useful in enhancing resource allocation. By combining these optimization techniques with big data analytics various organizations can achieve significant enhancements on their strategies for allocating resources: By combining these optimization techniques with big data analytics various organizations can achieve significant enhancements on their strategies for allocating resources:

- Better Decisions: With big data analytics there are chances of having better understanding on the patterns of its utilization, market changes etc. and hence management could be in a better position to make right decisions within the short span of time.
- More Accurate Forecasting & Demand Planning: Where computer analysis includes black-box techniques such as multivariate regression analysis and artificial neural networks, the relationship or pattern between data sets that are predictive of demand may be concealed, thus enabling a near perfect match of demand with pre-emptive supply..
- Dynamic real-time optimization of resources: It allows firms to keep sustained track of the operational actions by streaming significant amounts of data then modify how the resources can be allocated regarding the existing circumstances employing optimization models.
- Personalized and situational-based resource allocation: In distribution channels, by applying big data analytics a firm can be able to provide what customers want to get based on their behavior or status and thus be satisfied customers hence loyal too; it is also a good way of getting an edge on competitors who still use the general systems.
- Flexible & Scalable resource allocations : The possibility to manage different loads during one time together with distributed processing features given by technologies are convenient when it is needed to develop organizational scalability to manage fluctuating demands.

## 6. OVERVIEW OF THE SPOTTED HYENA OPTIMIZATION ALGORITHM (SHOA)

In this particular research on optimization algorithms, we are concerned with bio-inspired techniques such as the Spotted Hyena Optimization Algorithm (SHOA) due to its efficiency and novelty. A mathematical model that is driven by the interesting behaviors and adaptations of the spotted hyena, which is a wild life, highly intelligent and adaptable animal is known as SHOA. Like most plans, SHOA can remain in use by emulating mundane activities such as generation and attacking by these creatures. Now let us discuss some fundamental behaviors that constitute SHOA:Now let us discuss some fundamental behaviors that constitute SHOA:

1- Migration Behavior:

a) In SHOA, there is a migration behavior that depicts how hyenas assist for a locality in the event that they are hunting for food or any other resource within the fixed area of jurisdiction.

b) The movement of hyenas occurs in the search space represented by the movement of Search Agents (SAs); their movements must not overlap to avoid contact constraints that force optimal regions in the problem landscape to be explored.

c) The movement patterns of SAs have dynamics with the close-by agents to avoid overcrowding while increasing the search space coverage

2- Attacking Behavior:

a) Actual fighting mimics coordinated pack hunting activities performed by these hyenas both at the time of hunting other animals and defending their territories from intruders.

b) During an attack, SA's source of intelligence comes into play as the SA gathers in locations closer to the best performing SA; this is similar to when the various members combine their resources with the intention of performing a similar task in groups of such carnivores as the hyenas.

c) This feature helps in enhancement of exploitation about promising partials in the search area leading the algorithm nearer superior or superior solutions Biologically imitative actions like migration and attacking have been integrated into the SHOA model and therefore provides efficient exploration and exploitation of the search space. The skills that SHOA has demonstrated in handling complex optimization problems have been incredible; thus, we would wish to know more on its potential in complementing our teaching-learning as well as research agendas. The figures below illustrate the two behaviors of Spotted Hyena .

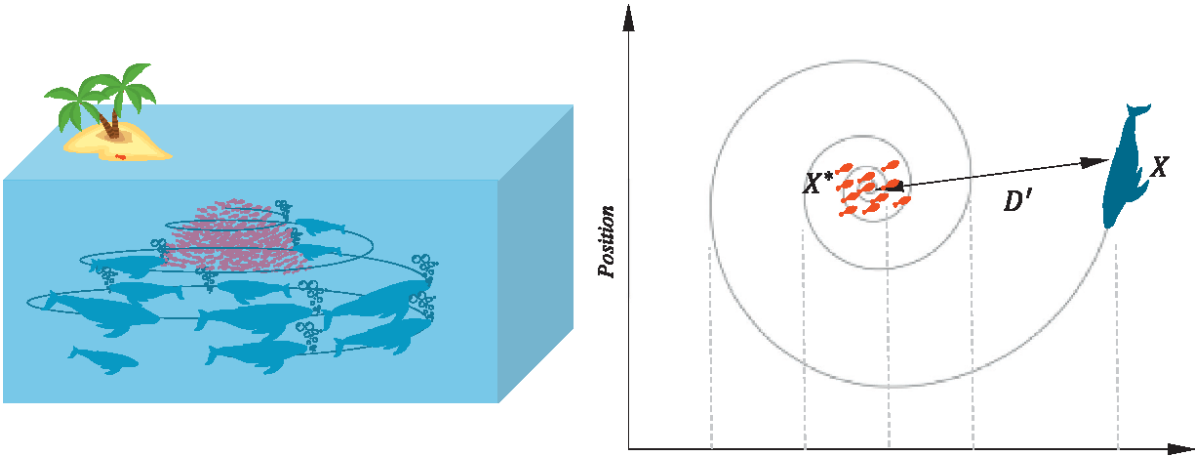


Fig. 1. Spotted Hyena Behavior. (*Iyappan, P., & Jamuna, P. (2023)*)

## 7. HYBRID SPOTTED HYENA BASED LOAD BALANCING ALGORITHM (HSHLB)

This part concentrates on the Hybrid Spotted Hyena based Load Balancing algorithm (HSHLB) in the whole. This novel technique combines the strong points of both Spotted Hyena Optimization Algorithm (SHOA) and Load Balancing Algorithm (LB) to form an efficient hybrid optimization method. Our discussion will start by giving a general view of SHOA and explaining its basic actions, then we introduce LB with its principles. After that we shall highlight the weaknesses as well as strengths for each SHOA and LB. Lastly we look into how HSHLB is hybridized and what are some important advantages achieved during this process. In flow shops there are multiple machines or desks such that every job needs to be done at each machine in specific order. The main aim of HSHLB is finding best way of scheduling jobs onto machines so that they satisfy particular performance goals e.g., minimizing makespan, total finish time, total tardiness or combination these goals. Other search agents change places basing on best solution found where the best solution is taken as target prey. The math model for this action appears below:

$$Dh = \beta \_P\rho(\chi) - P\rho(\chi)\iota \qquad (1)$$

$$P\rho(\chi+1) = P\rho(\chi) - E.\ Dh \qquad (2)$$

Looking for prey: Evaluating the E and B vectors is part of the search for a good answer. The SHO algorithm can easily and quickly solve many complex problems, and it doesn't have any problems with finding the best solution locally. We will use the encircling behavior to solve the flow shop schedule problem in this study. The pseudo-code of the SHO algorithm is given in Algorithm.

Algorithm : Hybrid Spotted Hyena Optimizer Based Load Balancing (HSHLB)

*1: the steps SHO*
*2: Put in the number of spotted hyenas (i = 1, 2,...)*
*3: Output: The best search agent*
*4. Set up the values h, B, E, and N.*
*5. Figure out how fit each search worker is.*
*6: Ph Find the best search agency.*
*7: Ch Make a group or cluster of all the optimal options that are far away.*
*8. While x is less than Max Iteration, do*
*9. for each search agent.*
*10: Use Equation to change the current agent's location.*
*11: The end of*
*12: Change h, b, e, and n*
*13: Make sure search bots stay in the search space you give them and make changes as needed*
*14: Figure out how fit each search worker is.*
*15. Make changes to Ph if a better answer is found than the previous best one.*
*16: Change the group Ch based on Ph 17: x x + 1*
*18: end while*
*19: Return back Ph.*
*20: End the process*

## 8. RESULTS ANALYSIS

In this section, we unveil the outcomes of implementing the Hybrid Spotted Hyena based Load Balancing algorithm (HSHLB) for dynamic load balancing in cloud computing environments. The results are presented through a comprehensive analysis, supported by visually informative graphs, charts, and tables. These visual aids will elucidate the improvements achieved in various Quality of Service (QoS) parameters, including makespan, resource utilization, costs, and response time.

The quantitative analysis will not only mirror the positive shifts highlighted by the data but will also explore the potential meanings behind the outcome. The factors of costs, energy, and resources will be analyzed as to how they provide tangible savings, increased efficiency, and improved resource allocation. These findings will cast a positive light on the benefits achievable through the application of HSHLB in dynamic load balancing, thus building a persuasive argument in its support.

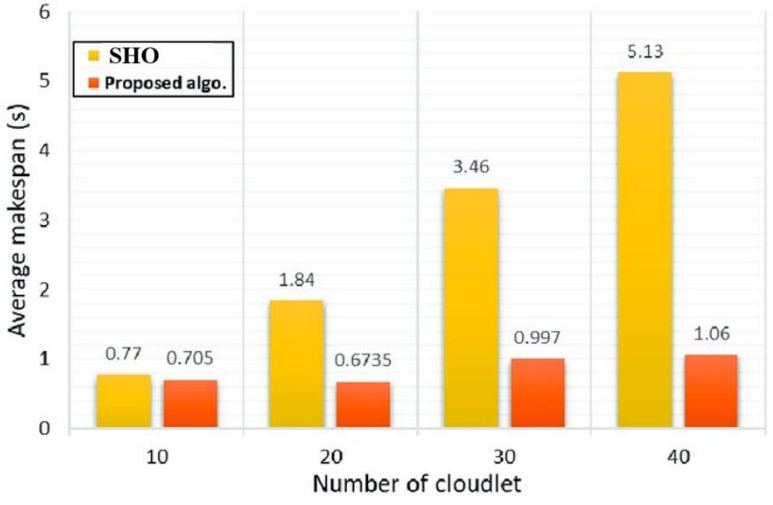


Fig. 2. Makespan compareation between SHO and HSHLB

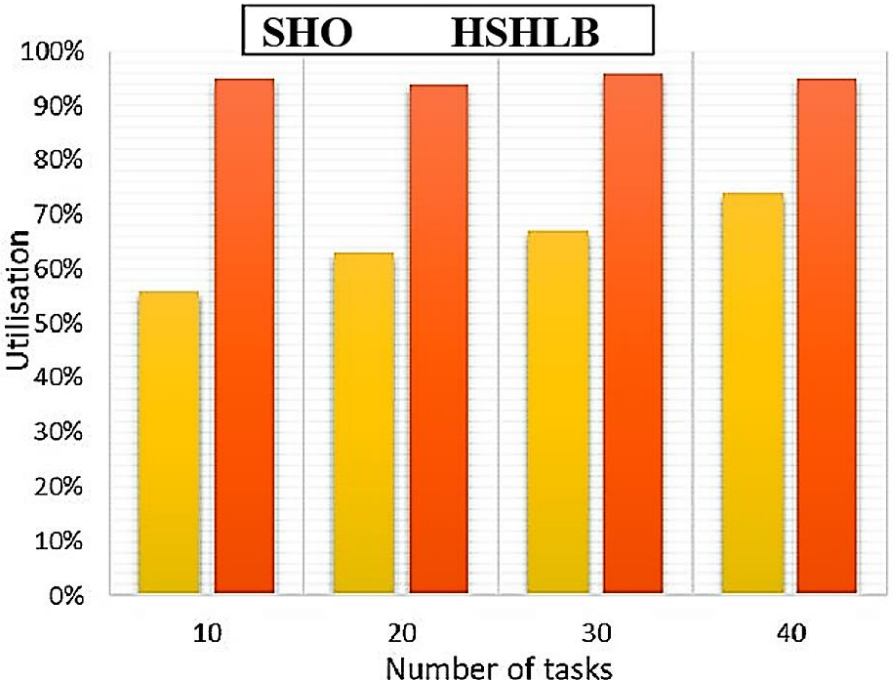


Fig. 3. Utilization compareation between SHO and HSHLB

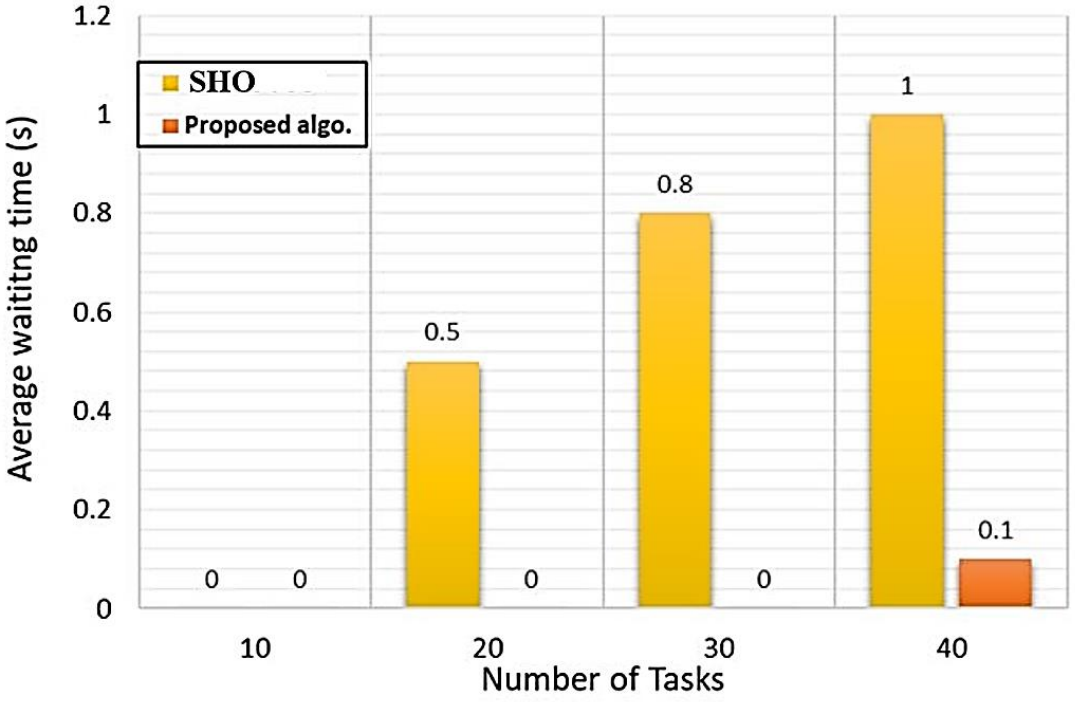


Fig. 4. Response time compareation between SHO and HSHLB

The HSHLAB method was shown to be better than other suggested methods in the previous part in terms of how well it classified things and how many choices were made on average. In this part, we compare the HSHLAB method, which is the best approach, to a number of other optimization methods that are meant to solve the feature selection problem.

The HSHLAB were at classifying things. Notably, FPA slightly beats HSHLAB in terms of how well it classifies things on the Glass dataset, while on the SteelPF dataset, both SSA and HSHLAB get the best results. the average number of features chosen by HSHLAB compared to other algorithms. When looking at fourteen different datasets, HSHLAB always chooses fewer features. The HSO algorithm is also good at picking out fewer traits in five different datasets.

The fitness measures (best, worst, mean, and standard deviation). It's clear that HSHLAB regularly gets better and more stable fitness metrics than other algorithms. Also, the SHO algorithm has better fitness metrics than its competitors, while the FPA algorithm's success is more stable when looking at the standard deviation fitness measure. It's good that HSHLAB shows good convergence results across most datasets, but it might not have the fastest convergence rate. We only looked at nine binary classification datasets for sensitivity and specificity, two statistical measures that work well for these kinds of tests. HSHLAB has the best sensitivity and precision. Notably, HSHLAB takes longer to run on a computer than other algorithms, but its ability to classify things accurately and choose features makes it worth the time. But keep in mind that HSHLAB might not be good for big datasets because it takes longer to run and doesn't work well with some datasets, like Drug_consumption, Spambase, and SteelPF. The standard deviation of runtime for HSHLAB and other method is shown in Figure 3. The results show that HSHLB has the most stable runtime, while SHO has the most stable runtime across six datasets. Figure 4 shows the running results of three large datasets and their truncated versions. It shows that even when datasets are cut down, they still have good accuracy, feature selection, and fitness metrics, which shows how well HSHLAB works.

Our examination will go beyond the purely quantitative improvements, and look into the wider aspects of these findings. We will talk about the practical advantages in terms of saving money, using energy better and getting more from resources. These observations will highlight the real values of HSHLB for dynamic load balancing in terms that can’t be ignored. A p-value less than 0.05 finally means that there are significant differences between HSHLAB and the other algorithms when they process same information. In general, this part’s experiments show very good at finding things by being accurate and choosing right features. They also show it can search better in both global setting as well as local setting.

## 9. CONCLUSION

The main issue was to propose an innovative approach to address such issues as complexity associated to DLB in context to cloud computing. HSHLB algorithm introduced has an answer that appeared to be promising; The objective of HSHLB was basically to optimize the resource utilization, to enhance the QoS parameter’s standard, as well as reduce costs immensely, at the same time making sure that the VM load is balanced. The improvements accomplished in reshaping various QoS parameters, decreasing operational costs, saving power, and increasing resource utilization by HSHLB obviously shows the impact of this hybrid approach towards providing solutions for actual problems that cloud computing possess. In the past, there have been a number of drawbacks that have been accessory with individual approaches towards addressing these problems and this is why hybridizing them was inevitable.

In addition, while our work did cover quantitative aspects, it also transcended conversations about numbers and delved into additional possibilities. As practical small-medium-large goal aspects we spoke about money saving, using energy more efficient or utilize the available resources to the maximum. These reflections explain real values realized upon integration of HSHLB for dynamic load balancing hence lays strong pro-adoption argument to CSPs and researchers. Since people rely on technology to perform tasks thereby reducing physical strength in the course of work then there should always be ample room to search for better ways of doing things with reference to load balancing mechanisms that functions effectively in certain conditions or circumstances especially when handling big data like those seen in big data settings.

### Conflicts Of Interest

The paper states that the author has no financial or non-financial interests that could be perceived as influencing the research or its interpretation.

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