# Efficient Load Balancing Technique using WOA in Cloud Computing

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**Abstract-** Cloud Computing is an on-demand type of service which provides services or software to end user whenever he requires and demands it. The term Cloud is used for service providers who have all type of resources for storage, computing and service providing. For realizing full capacity in cloud computing, it needs to support different services such as security, uniform access, task scheduling, resource management, economic computation etc. In this work we worked to minimise the energy consumption in cloud data centres The newly developed whale optimisation algorithm (WOA) is used to assign the VM to physical nodes for maximum utilisation of two resources within available capacity of system. We have compared WOA with Genetic Algorithm (GA) on various parameters and found good results for WOA.

**Keywords-** WOA, GA.

## I. INTRODUCTION

The cloud computing relies on the thought of dynamic provisioning that is applied to services, computing capability, storage, networking, and data technology infrastructure to fulfill user needs. The resources are created offered for the users through the web and offered on a pay-as-use basis from completely different Cloud computing vendors. Cloud computing infrastructures are designed to support the accessibility and preparation of assorted services orientating applications by the users. Cloud computing services are created offered through the server corporations or knowledge centres. to fulfill the growing demand for computations and enormous volume of information, the cloud computing environments provides high performance servers and high speed mass storage devices [1-2]. These resources are the key supply of the ability consumption in knowledge centres alongside air-con and cooling instrumentation. what is more the energy consumption within the cloud is proportional to the resource utilization and knowledge centres are virtually the world's highest shoppers of electricity [5]. because of the high energy consumption by knowledge centres, it needs economical technology to style inexperienced knowledge centre. On the opposite hand, Cloud knowledge centre will cut back the full energy consumed through task consolidation and server consolidation mistreatment the virtualization by workloads will share constant server and unused servers may be converted. the full computing power of the Cloud knowledge centre is that the total of the computing power of the individual physical machine. Clouds uses virtualization technology in knowledge centres to portion resources for the services as per want. Clouds provides 3 levels of access to the customers: SaaS, PaaS , and IaaS. The task originated by the client will take issue greatly from client to the client. Entities within the Cloud are autonomous and self-interested; but, they're willing to share their resources and services to attain their individual and collective goals. In such an open surroundings, the programming call may be a challenge given the suburbanized nature of the surroundings. every entity has specific needs and objectives that require to attain. Server consolidations are permitting the multiple servers running on one physical server at the same time to reduce the energy consumed in a very knowledge centre. Running the multiple servers on one physical server is completed through virtual machine thought. The task consolidation is additionally called server/workload consolidation downside. Task consolidation downside self-addressed during this thesis is to assign n task to a collection of r resources in cloud computing surroundings. This energy economical resource allocation maintains the employment of all computing resources and distributes virtual machines in a very manner that the energy consumption will minimize. The goal of those algorithms is to keep up accessibility to work out nodes whereas reducing the full energy consumed by the cloud infrastructure. Efficient load balancing using different methods in cloud computing is implemented by [1-10]. But no one implemented WOA in cloud environment to test the results of this newly introduced algorithm.

In this paper we have implemented cloud environment and tested it using newly introduced Whale Optimization Algorithm (WOA). We have used two resources first one CPU and second one is disk which is allocated to each Virtual Machine (VM). Performance of load distribution and balancing is compared with genetic algorithm (GA) which is standard optimization algorithm.

## II. WHALE OPTIMIZATION ALGORITHM (WOA)

Meta heuristic optimization algorithms are becoming more and more popular in optimization of engineering problems. Newly introduced optimization algorithm is whale optimization which was first introduced by [11]. In WOA humpback whales are taken as inspiration for reaching optimization. Their first step towards prey is encircling the target. They recognize the location of prey and start encircle them. So WOA algorithm also assumes that current best candidate solution is the target prey and very close to optimum value. When best search agent is defined other search agents will try to update their positions towards the best search agent. This can be represented by following equations.

$$D = |C.X^*(t) - X(t)| \quad (1)$$

$$X(t+1) = X(t) - A.D \quad (2)$$

Where t is the current iteration

A and C are coefficient vectors

$X^*$ is best solution obtained so far

X is the position vector

$X^*$ should be updated in every iteration if there is a better solution.

A and C can be calculated using following equations

$$A = 2a.r - a \quad (3)$$

$$C = 2.r \quad (4)$$

Where $a$ is linearly decreased from 2 to 0 over the course of iteration$r$ is a random vector in [0,1]The position (X,Y) of a search agent can be updated by taking reference to the position of the current best record $X^*Y^*$. Different positions around the best agent can be achieved with respect to current position by changing values of A and C. By suitably defining the value of $r$ random vector, it is possible to reach any position in the search space. So equation (2) allows any search agents to update their position in the near places of current best solution and it simulates encircling the prey.

A. Bubble net attacking method (Exploitation phase)

Humpback whales depict bubble net behaviour which can be shown by two approaches.

(i) Shrinking encircling mechanism- This behavior can be achieved by decreasing value of $a$ in equation (). So, fluctuation range of A also decreased as range of A is $[-a, a]$ where a is decreased from 2 to 0 over the iterations. By setting random values for A in [-1,1], the updated position of a search agent can be defined anywhere in between the original position of the agent and current best position of agent.

(ii) Spiral updating position- This approach first calculates the distance between the whale located at (X,Y) and prey located at ($X^*Y^*$). Spiral equation is given here which shows the movement of humpback whales.

$$X(t+1) = D'.e^{bl}.\cos(2\pi l) + X^*(t) \quad (5)$$

Where $D' = |X^*(t) - X(t)|$ and it indicates the distance of ith whale to the prey which is best solution obtained so far.$b$ is a constant for defining the shape of the logarithmic spiral $l$ is a random number in [-1,1]

Humpback whale swim around the target within shrinking circle on spiral shaped path simultaneously. Here it is assumed to have 50% probability to choose between spiral model and shrinking encircle mechanism which can be represented in the form of equation as given here.

$$X(t+1) = \begin{cases} X^*(t) - A.D & if \ \ p < 0.5 \\ D'.e^{bl}.\cos(2\pi l) + X^*(t) & \text{if } \ p > 0.5 \end{cases} \quad (6)$$

Where p is a random number in [0,1].

B. Search for prey

It is also called exploration phase where humpback whale search for its prey. Actually humpback whales search randomly for prey. So, we use A with random values between [-1,1] to force search agent to move everywhere from whale. As in exploitation phase , we here update the position of a search agent in exploration phase according to randomly chosen search agent not best search agent found so far. This mechanism can be described using equation given below.

$$D = |C.Xrand(t) - X| \quad (7)$$

$$X(t+1) = Xrand(t) - A.D \quad (8)$$

$Xrand$ is a random position vector may be nominated as random whale chosen from current population. So, WOA algorithm can be summarized as follows: The WOA algorithm initialize with a set of random solutions. Maximum number of iterations are to be set and for each iteration, search agents update their current position with respect to best solution obtained so far. The a parameter is decreased from 2 to 0 to provide exploration and exploitation. Now, a random search agent (whale) is chosen to initialize and updates the position of search agent while |A|<1. Depending upon value of p, WOA can switch between either a circular movement or spiral movement. WOA algorithm may be terminated by termination criterion or maximum number of iterations are over.

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## III. PROPOSED WORK

We implemented Genetic Algorithm (GA) algorithm in a cloud environment having 10 VMs. We compared performance of GA with WOA with the help of objective cost function which was Euclidean distance between physical node and server. Our objective was to test efficient load balancing technique which will minimize this objective function.

Table 1: Input Parameters considered for cloud computing data center

| | |
|---|---|
| Number of VMs | 10,20,30,40,50,60,70 |
| Number of physical nodes | 100 |
| Number of resources | 2 (hard disk, CPU) |
| Best resource utilization ratio (hard disk, CPU) | [0.5,0.7] |
| Capacity of physical nodes | [2260 MIPS,21000 TB] |

Table 1 show the input parameters used to test the algorithm in cloud computing case. We have taken seven cases where we increased VM by 10 in each case from previous case. These cases are 1020,30,40,50,60,70. We want to check what will be effect of implementation when complexity of network increases. To test variable number of VM performance we have taken constant number of physical nodes as 100. Two resources are used to judge performance of VM which are CPU and Hard Disk with corresponding utilization factors of 0.5 and 0.7 respectively. Capacity of resource d=should be in limits to check the performance, so CPU capacity is taken as 2260 MIPS and Hard Disk capacity is taken as 21000 TB. Third parameter is based on these two primary parameters, this third parameter is Euclidean distance which is distance between virtual machine and physical node. This distance is to be minimized while other two parameters, CPU utilization and Hard Disk utilization should be maximized. The Euclidean distance as given in equation (9).

$$\delta = \sum_{i=1}^{n} \sqrt{\sum_{j=1}^{d} (u_i^j - ubest_i)^2} \quad (9)$$

Where n is the dimension which denotes kinds of resources, such as CPU, disk, memory, and bandwidth, d denotes the number of hosts in cloud data centre. $u_i^j$ is the utilization for host j and the resource i, $ubest_i$ is the best utilization for $u_i^j$. The total Euclidean distance denotes the optimal balance between multi-resources utilization and energy consumption. Minimizing the total Euclidean distance will get optimal energy efficiency in the whole system. In this situation, the multi-resources energy efficiency model is described as follows:

$$objective : min\ \delta \quad (10)$$

$$constraints : x_h^j = 0 \quad (11)$$

Where $x_h^j$ denotes virtual machine VM allocated to node $h$ ;

$x_h^j = 0$ denotes VM is not allocated to resources

Equation 4.3 states that each VM can be allocated to one node only. In order to satisfy the limitations, each resource must satisfy the following inequality constraints as follows:

$$\sum_j r_j^{CPU} * x_h^j \le c_h^{CPU}, \quad \sum_j r_j^{RAM} * x_h^j \le c_h^{RAM}, \quad \sum_j r_j^{BW} * x_h^j \le c_h^{BW}, \quad \sum_j r_j^{DISK} * x_h^j \le c_h^{DISK}, \quad (12)$$

Here in this expression $r_j^{CPU}, r_j^{RAM}, r_j^{BW}, r_j^{DISK}$ denotes the demand of resources and $c_h$ denotes the capacity of these resources. The above expression must be satisfied while assigning optimal nodes to VMs. The capacity is the maximum resource available to allot to VMs. We have taken only two parameters to avoid complexity. So, we will take CPU utilization and Hard Disk utilization. The maximum and minimum allotted capacities of these are given in table 2.

Table 2: maximum and minimum limit of resources allocated to each VM

| | | Low | High |
|---|---|---|---|
| 1 | CPU (MIPS) | 60 | 150 |
| 2 | Disk (TB) | 100 | 200 |

Each VM must be allocated the available resources within this range. So, this problem has many constraints to fulfil and object to minimise the Euclidean distance, it becomes the NP hard problem and whale optimization is used in our proposed work to solve equation (9).

## IV. RESULTS

In this section we have compared results obtained for different number of VMs and their effect on load balancing by using WOA and GA.

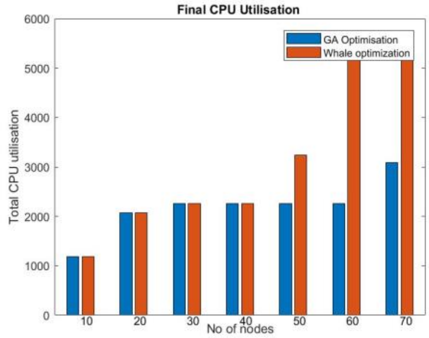


Fig 1: CPU utilization with respect to number of VM for GA and WOA

Figure 1 shows different values of CPU utilization for different values of virtual machine taken with number of physical nodes remained 100. It can be analysed from figure that for less number of VM i.e. cases of 10,20,30,40, we got same results of CPU utilization for both the algorithms but when we increase number of VMs to 50,60,70 we get improved results for whale optimization than genetic algorithm. So, we can conclude that for larger cloud network where number of VM are larger WOA gives better optimization results than GA.

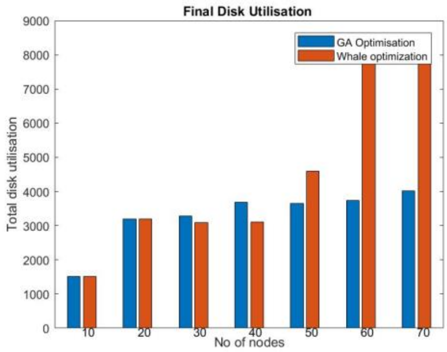


Fig 2: Disk utilization with respect to number of VM for GA and WOA

Figure 2 shows different values of disk utilization for different values of virtual machine taken with number of physical nodes remained 100. It can be analysed from figure that for less number of VM i.e. cases of 10,20,30 we got same results of CPU utilization for both the algorithms but for 40 we get slightly opposite results when we increase number of VMs to 50,60,70 we get improved results for whale optimization than genetic algorithm. So, we can conclude that for larger cloud network where number of VM are larger WOA gives better optimization results than GA.

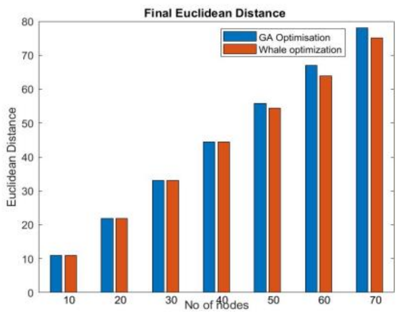


Fig 3: Euclidean distance with respect to number of VM for GA and WOA

Euclidean distance is our objective function which is to be minimized by optimization algorithm. Figure 3 shows Euclidean distance for different number of virtual machine for the cases of GA and WOA. It is analysed from figure that Euclidean distance of starting four cases i.e. for number of VMs 10,20,30,40 are almost same but for larger number of VMs i.e.50,60,70 Euclidean distance for WOA is lesser than GA. It means for higher number of VMs and bigger cloud environment WOA provide better minimization using our chosen objective function.

Table 3-5 shows the exact value depicted in bar chart shown in figure 1-3. These Tables are given at last of this paper.

## V. CONCLUSION

It is concluded from results that when we increase number of VMs and increase complexity of cloud computing environment, WOA works well in load balancing as compared to GA algorithm. So, for heavy network with high traffic WOA can be implemented for efficient load balancing.

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Table 3 : Comparison of final CPU utilisation by both algorithms

| Number of virtual machines | WOA Algorithm (in MIPS) | GA Algorithm (in MIPS) |
|---|---|---|
| 10 | 10.8956215625072 | 10.8956215625072 |
| 20 | 21.8780268323950 | 21.8780268323950 |
| 30 | 33.1363640066306 | 33.1316174649529 |
| 40 | 44.4485372113987 | 44.4317887475051 |
| 50 | 54.4078356940035 | 55.7467463628362 |
| 60 | 63.8323310962177 | 67.0575152064800 |
| 70 | 75.1580847456362 | 78.1087120797624 |

Table 4: Comparison of final disk allocation by both algorithms

| Number of virtual machines | WOA Algorithm (in GB) | GA Algorithm (in GB) |
|---|---|---|
| 10 | 1520.03225130761 | 1520.03225130761 |
| 20 | 3188.05934595680 | 3188.05934595680 |
| 30 | 3094.26792857162 | 3284.37106674919 |
| 40 | 3100.88930262881 | 3692.95426313858 |
| 50 | 4600.67675175649 | 3652.09425043705 |
| 60 | 8047.52280735849 | 3730.52571669857 |
| 70 | 8421.92096797970 | 4020.32643634333 |

Table 5: Comparison of Euclidean distance by both algorithms

| Number of virtual machines | WOA Algorithm | GA Algorithm |
|---|---|---|
| 10 | 1188.44588308373 | 1188.44588308373 |
| 20 | 2075.44319374128 | 2075.44319374128 |
| 30 | 2259.99987946047 | 2259.03958391538 |
| 40 | 2261.58493958627 | 2257.25892842593 |
| 50 | 3245.11750515869 | 2258.20363655510 |
| 60 | 5747.78073265047 | 2256.65336059133 |
| 70 | 5668.85811298765 | 3082.89439962956 |