ISSN: 0976-3104
ISSUE: Computer and Allied Sciences

ARTICLE

MATHEMATICAL APPROACH TOWARDS RECENT INNOVATION IN COMPUTATION AND ENGINEERING SYSTEM (MATRICS)

OPTIMAL WHALE OPTIMIZATION ALGORITHM BASED ENERGY EFFICIENT RESOURCE ALLOCATION IN CLOUD COMPUTING ENVIRONMENT

Natarajan Subalakshmi[1], Mohan Jeyakarthic[2*]

[1]Computer Science and Engineering Wing, Annamalai University, Chidambaram, TN, INDIA
[2]Tamil Virtual Academy, Chennai, TN, INDIA

ABSTRACT

In cloud, proper allocation of resources improves the exploitation of resources as well as energy efficiency, provider's profit and client's fulfilment. Whale Optimization Algorithm (WOA) is a new bio-inspired meta-heuristic technique inspired from the social hunting nature of humpback whales. WOA suffers premature convergence that causes it to trap in local optima. To resolve it, this paper proposes a new energy efficient resource allocation in cloud computing environment using optimal whale optimization algorithm with tumbling effective called WOA-TRA model. Here, the WOA is hybridized with tumbling effect which has good exploration ability for function optimization problems to derive an energy aware solution. The proposed WOA-TRA model methodology attempts to optimize allocation of resources for improving the energy efficiency of the cloud platform by fulfilling the quality of service (QoS) requirements of the end user. To effectively utilize the energy and QoS requirements, the WOA-TRA technique is utilized in two levels. In the first level, WOA-TRA technique assigns Virtual Machines (VMs) resources to jobs, whereas in second level, WOA-TRA technique assigns Physical Machines (PMs) resources to VMs. The presented model is simulated in CloudSim platform and a detailed comparative analysis is made with the state of art resource allocation techniques. The experimental analysis states that the presented WOA-TRA technique offered desired QoS and enhanced energy efficiency by effectively utilizing the available resources over the compared methods.

KEY WORDS
Resource allocation, Energy aware, Whale optimization, Local optima

Received: 26 June 2020
Accepted: 18 July 2020
Published: 22 July 2020

***Corresponding Author**
Email: Jeya_karthic@yahoo.com
Tel.: 8667859294

INTRODUCTION

Infection Cloud Computing (CC) is a model which consists of massive ability in trading and business. It contains maximum number of certain resources that could be obtained and utilized whenever the demand arouses [1]. The obtained resources could be used across the network. Cloud presents every source as service and is comprised of three services namely Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). The IaaS performs basic operations such as computation, memory, networking and so on. They are offered to the customers in order to deploy as well as to implement software randomly [2]. Here, the resources are planned definitely and assigned on the basis of customer demands. Therefore, the purpose of allocating resources ensured the requirement of every application processing. Since the above operations are performed, resource allocation in CC is a mandatory issue. Regardless of allocating resources, allocating enough resource for user demand to convince quality of service (QoS) attributes is an alternate challenge for an organization to reduce the power consumption as well and carbon footprints.

Based on the statement of [3], entire data centre energy conservation from servers, memory, interactions, resolving, and power-distributing tools considers 1.7–2.2% of total power applied in US. Using the numerous amount of energy, present data centre release maximum carbon dioxide (CO_2) thought Argentina. When it is left on present path, data centre carbon-dioxide outcome would increase widely by 2020 [4]. Since there is rapid development of cloud, industries, and research institutes identify the feasible paths to minimize the power utilization. Data centres construction is normally prepared for retaining resources in peak time [5]. Energy efficiency could be enhanced by optimally balancing the resources. In order to reduce maximum power utilization, resource allocation should be efficient. Massive amount of energy could be stored by consolidating server as well as switching off unique servers. But, consolidation of servers are possible financially due to some limitations namely cost of migrating, violating QoS as several disturbances occurs while performing final process of physical machines (PM) using enough resources, so that virtual machine (VM) could be transferred easily. At this point, energy conserved by PM could be stored by varying the corresponding voltage.

Beloglazov et al., 2012 [6] presented an energy effective as well as QoS aware resource allocating technique absed on heuristics. A technique for reducing number of VM has also been deployed. Lower and upper threshold consumption has been fixed in order to predict the underweight and overloaded systems. If any server drops below the specified threshold level, then each VM implemented on the system is transferred to alternate machine whereas the resource conservation is above the threshold value then more than single values are transformed among the values. Practically cloud platforms identical multi-core machines are utilized. The VM is placed for reducing the resource wastage as well as energy conservation. The first pheromone value is declared to VM-host transformation. This value denotes the possibility of a host which is to be chosen to allocate VM with certain constraints. This technique operates using central processing unit (CPU) operation, speed, storage and so on.

THE IIOAB JOURNAL

EDITED BY: Prof. Dr. S. Vaithyasubramanian

In Kinger et al., 2014 [7], an event driven detection model has been proposed to maintain the temperature of a server with particular threshold values. Temperature predictor often observes the temperature of external system. In this model "unified list" has been applied for storing electricity and threshold temperature for all nodes. It is usually upgraded once the duration is fixed that leads to network congestion, degrading performance, restricted scalability and so on. Quarati et al., 2013 [8] projected 2 stages of brokering algorithm for hybrid cloud along with the intention of increasing brokers economy rate as well as customer convenience. Initial stage is to schedule the requested facilities on private or public cloud which is done on the basis of predefined resources. Further division from first stage of cloud namely possibility, reservation should be static and effective. The next stage is to apply lower resources in order to declare the resource for every service. Hence, requested services are executed on the physical system which consists of improved assessable sources. The deployed model leads to dissimilar distribution of overhead between servers and the machines that are operated with high efficiency. Overload tends to cause hot spot issue and raise the level of failure.

Lee et al., 2014 [9] applied the computation model that relies on resource allocating principle for green cloud. All PMs of a data centre are allocated with a performance measure that depends upon the processing speed of CPU, count of cores, storage ability and so on. Any PM could be assigned to VM, when the performance value is accurate to VM necessities. Improper sharing of overhead between servers might leads to power wastage. Raycroft et al., 2014 [10] examined the impact of VM allocating that is based on consumption of energy. Here, simulating operation is carried out for similar kind of applications whereas realistic clouds conduct different types of application. The communication cost between VM and QoS is not considered. Therefore, the movement of VM between areas becomes impractical when it comes to massive size of VM. Feller et al., 2011 [11] employed multi-dimensional ant colony optimization (ACO) that is relied on workload consolidating technique. This technique applies the resource consumption in order to detect the upcoming demands of resource.

Gao et al., 2013 [12] signified the multi-objective ACO model for virtual system to be fixed. Using this placement, it reduces the wastage of resource and energy application. It has the objective of utilizing server to complete ability that results in creating hot spots as well as maximizes service-level agreement (SLA) violations. With the application of complete usage of server it causes major heat disperse that tends to minimize the servers consistency. Nathani et al., 2012 [13] introduced alternate and latest consumption methods for end sensitive lease of VM. The proposed model attempts for scheduling novel lease as deadline in more than one time slots. To create a new room for novel lease, the algorithm reallocates the previously scheduled deadline sensitive leases in case if it could not be declared to single or multiple time slots. If reallocation is carried out properly i.e., fails to produce limited deadline schedule and backfilling is used to accompany new lease. Proposed model is emerged with a demerit where it consumes maximum pre-emption value that improves overhead.

ACO model is applied for heterogeneous operators which are implied in Chen et al., 2011 [14]. Local search method is used for enhancing the efficiency of energy when there is possible declaration decision produced by new technique. This model is claimed with 15.8% energy than prototyped model of ACO. Huang et al., 2013 [15] adapted a sub-optimal resource managing approach. Here, wide resource scheduling module applies residual resource table as well as resource utilization measuring table in order to evaluate VM which is essential to offer defined level of services. Genetic Algorithm (GA) is developed to reallocate resources for attaining optimal computation. However the newly presented model meets the failure of single point. Therefore, centralized global resource scheduling method, residual resource table, as well as resource consumption table would create decreased performance while maximum requests arise in VM.

Garg et al., 2011 [16] presented green CC technology to minimize carbon footprint with inconvenient QoS. This research applies Green Offer Directory (GOD) and Carbon Emission Directory (CED) in order to provide green facilities for the customers. The CED balances information which is relevant to energy efficient cloud service. According to the data from 2 repositories, price as well as carbon footprint of particular leasing is estimated. Hence, providers have the responsibility of publishing footprint as well as effective energy for corresponding public directories. Thus service provider could publish the modified information to gain maximum standard in market. Xu and Fortes, 2010 [17] established different objectives for VM allocating technique. By the consumption of disk, inter VM interaction cost is not considered. Wu et al., 2014 [18] projected priority job scheduling in a effective manner for CC. CPU frequencies in terms of maximum and minimum are preferred as the essential features to perform this priority scheduling job. Each server is declared with few weights on the basis of computation obtained. In order to perform the job, server should be chosen on the basis of weight assigned as well as SLA needed by customers.

This paper introduces a whale optimization algorithm for resource allocation problem in cloud environment. WOA is a new bio-inspired meta-heuristic technique inspired from the social hunting nature of humpback whales. WOA suffers premature convergence that causes it to trap in local optima. To resolve this issue, this paper this limitation of WOA, in this paper, WOA is hybridized with tumbling effect which has good exploration ability for function optimization problems and derives a WOA with tumbling effect based energy aware solution called WOA-TRA model. The proposed WOA-TRA model methodology attempts to optimize allocation of resources in for improving the energy efficiency of the cloud platform by fulfilling the quality of service (QoS) requirements of the end user. To effectively utilize the energy and QoS requirements, the WOA-TRA technique is utilized in two levels. In the first level, WOA-TRA technique assigns

Virtual Machines (VMs) resources to jobs, whereas in second level, WOA-TRA technique assigns Physical Machines (PMs) resources to VMs. The presented model is simulated in CloudSim platform and a detailed comparative analysis is made with the state of art resource allocation techniques. The experimental analysis stated that the presented WOA-TRA technique offered desired QoS and enhanced energy efficiency by effectively utilizes the available resources over the compared methods.

The presented WOA-TRA model

The presented WOA-TRA framework assigns the resource for all jobs with the application of ACO. The resources are employed efficiently in order to store energy and satisfy the demands of every job. Every job is comprised with few resources as well as QoS necessities. The QoS parameter of a job is connected with weight value. WOA-TRA assigns resources for jobs based on the demand for resources and weight values of QoS attributes. Some of the significant features of WOA-TRA are listed as follows:

- It simply allocates the sources for job to enhance the application of resources which maximizes the energy efficiency of cloud structure.
- In order to save energy idle PM is turned to sleep mode.
- Observing the use of resources for processing unit, storage, internet bandwidth of a PM to attain effective resource allocation.
- Dynamic scaling operation is carried out to preserve energy.
- Consolidation of server helps in reducing active servers.

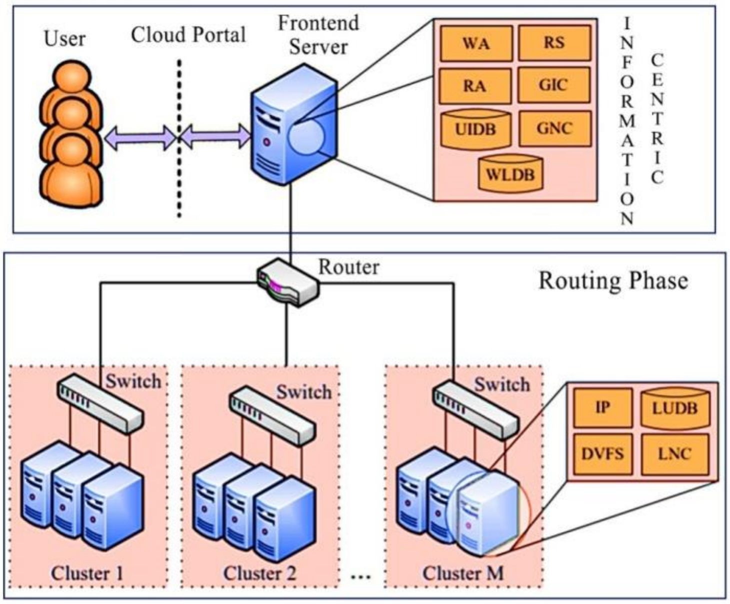

Fig. 1: Components in WOA-TRA model

The different number of components involved in WOA-TRA model is shown in [Fig. 1] and the basic steps involved in the resource allocation process is shown in [Fig. 2].

Cloud Portal: It offers an interface for cloud consumers in order to induce their corresponding job and fixed QoS.
Workload analyzer (WA): It examines essential QoS features of jobs and divides into various classes with the help of k-means clustering technique.
Resource scheduler (RS): It produces job scheduling execution process.
Resource Allocation (RA): This model employs ACO for allocating jobs to VM, where VM in turn assigns to PM. Resource allocation is performed on the basis of demands and values of QoS attributes which is linked with a task.
Global information collector (GIC): It obtains a resource application information form information probes (IP) of all PM as well as saves in Utilization Information Database (UIDB).
Utilization information database (UIDB): Data regarding resource application for each PM is recorded in UIDB, which could be acquired for future allocation and VM transforming solutions.
Global node controller (GNC): It starts current migration of VM executing on PM while resource utilization of PM violates Lower Green Threshold (LGT) or Upper Green Threshold (UGT) limit.
Workload database (WLDB): It is helpful in saving the data regarding every job.
Information probes (IP): It observes the use of resource by processors, memory, network bandwidth of PM and saves monitored values in Local Utilization Database (LUDB).
Local utilization database (LUDB): Application of resource of PM is stored in this feature.

IIOAB JOURNAL
ISSN: 0976-3104

Dynamic voltage frequency scaling (DVFS): It helps to adapt the voltage and frequency of PM for energy conservation as well as to minimize the heat dispersion. Voltage of PM could be modified based on the resource demand of VM implementation.

Local node controller (LNC): It turns PM to sleep mode when it is identified as unique for particular interval of duration.

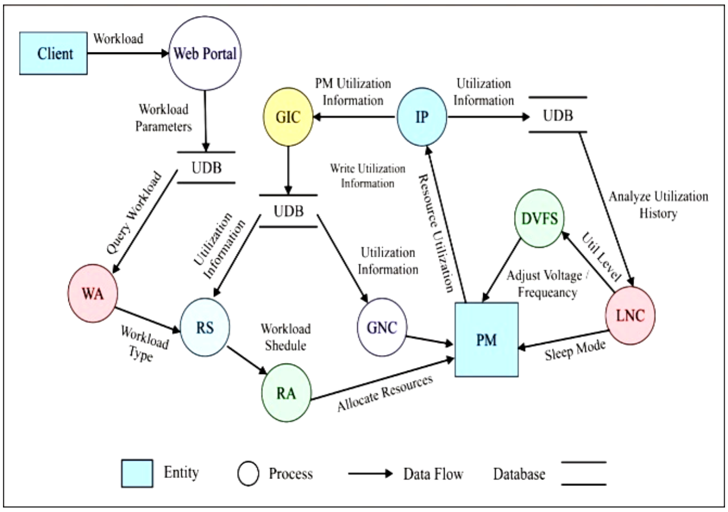

Fig. 2: Energy Based Resource Allocation Steps

The main intention of proposed model is to decrease energy conservation, entire implementation time, cost spent for execution by effective application of resources. Here, weighted addition is applied in order to scale different objectives into one resource.

Inspiration of WOA

Whale is treated as the largest mammals in the world. A mature whale could develop to a maximum of 30m long with180t weights [19]. There are seven various important types of huge mammal namely killer, Minke, Sei, humpback, right, finback, and blue. Whale is generally treated as killers. They do not sleep, as they should breathe from the surface of oceans. In reality, half of the whale's mind only sleeps. The most amazing factor is that they are extremely clever mammals with feeling. The exciting things on humpback whales are their individual hunting technique. This hunting process is termed as bubble-net feeding model. Humpback whales choose chasing school of krill's otherwise little fishes nearby surface. It has been monitored that hunting's are completed with generating particular bubbles beside encircle otherwise '9'-shaped way. An interesting factor regarding this technique is bubble-net feeding which is identified only from whales; also the enhanced model of feeding is spiral bubble-net method which is developed for determining better optimizing function.

Mathematical concept and optimization technique

In this segment, the mathematical concept of surrounding victim, circling bubble-net feeding scheme and initial exploration of prey were discussed. The WOA techniques are then presented.

Encircling prey

Humpback whales could identify the victim location as well as surrounded them. Because of the fact that the location of best position in the exploration spaces are not known before, the WOA technique considers the present optimal candidate results as the victim otherwise nearby optimization. Behind the optimal exploring agents as described, the further exploration agents gets resolved,; hence, attempts for informing their locations towards the optimal explore agents. This performance is signified with subsequent equations:

$$\vec{D} = \left|\vec{C}.\vec{P^*}(z) - P(z)\right| \quad (1)$$

$$\vec{P}(z+1) = \vec{P^*}(z) - \vec{L}\cdot\vec{D} \quad (2)$$

where z denotes the present iteration, $\vec{L}$ and $\vec{C}$ are co-efficient vectors, P^* is the location vector of optimal result achieved until now, $\vec{P}$ is the location vector, $||$ is the total value, while . is the element-via-element multiplication. It is value for declaring now that P^* must be informed in all iterations when there is an optimal solution. The vectors $\vec{L}$ and $\vec{C}$ are computed as follows:

$$\vec{L} = 2\vec{l} \cdot \vec{r} - \vec{l} \qquad (3)$$

$$C = 2 \cdot \vec{r} \qquad (4)$$

where $\vec{l}$ is linear reduced from two to zero above the way of iterations (together searching and utilization stages) while $\vec{r}$ is a arbitrary vectors in [0, 1].

The location (P, Q) of a explore agents could be informed give to the location of present optimal records (P^*, Q^*). Several places about the optimal agents could be obtained in terms of the present location with changing the value of $\vec{L}$ as well as $\vec{C}$ vectors. It must be noticeable with interpret the arbitrary vector $(\vec{r})$ it is probable for reaching some location in the explore space located among the key points. Consequently, Eq. (2) permits several explore agents for updating its location in the region of the present optimal result as well as reproduces surrounding the victim. The similar method could be continuing for exploring spaces by n dimension, while explore agents would progress in hypercube about the optimal result achieved till now. As declared in the before segment, the humpback whales as well harass the victim by the bubble-net approach. These techniques are mathematically created as follows:

Bubblenet harassing technique

To mathematically define the bubble-net performance of humpback whales, 2 strategies are employed and the bubblenet exploration mechanism is shown in [Fig. 3] [19]:

Shrinking surrounding mechanism: These performances are attained with reducing the rate of $\vec{l}$ in the Eq. (3). Noticeable the variation series of $\vec{L}$ is also reduced with $\vec{l}$. In further words $\vec{L}$ is an arbitrary rate of interval $[-l, l]$ where l is reduced from two to zero above the iteration way. Surroundings arbitrary rates to $\vec{L}$ in [-1, 1], the novel location of a explore agents could be described wherever among the unique location of the agents while the location of the present optimal agents.

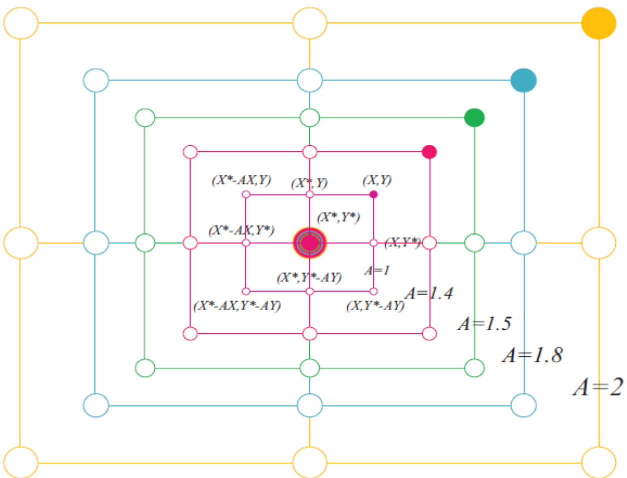

Fig. 3: BubbleNet explore mechanism

Spiral informing location: It computes the distance among the whale positioned at (P, Q) as well as victim positioned at (P^*, Q^*). A circling equations are then generated among the location of whale as well as victim for imitating the helix-shaped progress of humpback whales as pursues:

$$\vec{P}(z+1) = \vec{D'} \cdot e^{ba} \cdot \cos(2\pi l) + \vec{P^*}(z) \qquad (5)$$

where $\vec{D'} = \left|\vec{P^*}(z) - \vec{P}(z)\right|$ represents the distance of the ith whales to the victim (optimal result achieved till now), b is stability to define the form of the logarithmic circling, a is a arbitrary number in [-1,1], and . is an element-via-element multiplication.

Noticeably, humpback whales swims and encircle the victim in a decrease surround as well as beside a circling shape way at the same time. To concept this concurrent actions, we consider that there is a possibility of 50% of selecting among them either by decreasing the surrounding mechanism or the circling concept for updating the location of whales in optimization. The mathematical concept is as pursues:

$$P(z+1) = \begin{cases} \overrightarrow{P^*}(z) - \vec{L} \cdot \vec{D} & if\ x < 0.5 \\ \vec{D'} \cdot e^{ba} \cdot \cos(2\pi l) + \overrightarrow{P^*}(z) & if\ x \geq 0.5 \end{cases} \quad (6)$$

where x is an arbitrary number in [0, 1]. Besides the bubble-net technique, the humpback whales explore the victim arbitrarily.

Search for prey (exploration phase)

The similar manner dependent on the difference of the $\vec{L}$ vector could be used for exploring for victim. In detail, humpback whales explore arbitrarily give to the location of every other. Consequently, we utilize $\vec{L}$ by arbitrary values larger than 1 or smaller than -1 to force explore agent for moving isolated from a mention whale. In difference for utilization stage, we inform the place of a explore agent in the searching stage provided for an arbitrarily selection explore agent rather than the optimal explore agent found until now. This mechanism and $|\vec{L}| > 1$ underline searching as well as permit the WOA technique for executing a global exploration. The mathematical concepts are pursues:

$$\vec{D} = \left| C \cdot \overrightarrow{P_{rand}} - \vec{P} \right| \quad (7)$$

$$\vec{P}(z+1) = \overrightarrow{P_{rand}} \to -\vec{L}.\vec{D} \quad (8)$$

where $\overrightarrow{P_{rand}}$ is an arbitrary location vector (a arbitrary whales) selected from the present population.

A few probable locations surrounding an exact result by $\vec{L} > 1$. The WOA technique can be found by a group of arbitrary results. At every iteration, exploring agents inform their locations in terms of an arbitrarily selected explore either agent or optimal solution achieved until now. The attributes are reduced from two to zero that gives searching as well as utilization, correspondingly. An arbitrary explore agents are selected when $|\vec{L}| > 1$; as the optimal solutions are chosen when $|\vec{L}| < 1$ to update the location of explore agents. Based upon the value of$x$, WOA is capable to switch among also a circling or around association. At last, the WOA techniques are ended with the pleasure of a completion reason.

From hypothetical location, WOA could be measured a global optimization as it contains searching/utilization capacity. Besides, the presented hypercube mechanism describes a explore space in the region of the optimal result while allocates further explore agents for searching the present optimal list within that field. Flexible difference from the explore vector L allocates the WOA technique for easily transferring among searching as well as utilization: with reducing$L$, a few iterations are dedicated for search $(|L| \geq 1)$ while the rest is devoted for searching purposes $(|L| < 1)$. Extraordinarily, WOA contains only 2 important internal attributes to be changed $(L\ and\ C)$. Even though mutation and other development functions may contains WOA formulation for complete replicating the performance of humpback whales, we determined for reducing the sum of heuristics while the amount of interior attributes thus executing a very fundamental versions of the WOA technique.

The limitation of WOA lies in the local trapping of optimum values which is resolved by the use of tumbling effect. The new solutions are created by the use of bacterial foraging algorithm (BFO). The motion of bacteria in the human intestine while searching the nutrient rich location away from harmful place takes place by the use of locomotory organelles called as flagella through the chemotactic motion through swimming or tumbling. In the WOA-TRA model, the choice of whale motion will be decided using the fitness function. When the whales shift toward the optimal fitness value, then the motion of whales is called as swimming. In other cases, every whale follows the chemotactic motion of bacterium.

Two level resource allocation

This paper comprises WOA-TRA technique which is applied in 2 stages: Allocating VM resources to jobs, Allocation of PM resources to VM.

Allocation of VM resources to Jobs

Every task of the client requires some resource necessitates and QoS needs. Every QoS variable is linked to few values which represents the priority over the other ones. The weights of QoS properties could be represented in three types namely absolute weighting, relative weighting, and arbitrary weighting. Here, relative weighting is applied to represent QoS variables. The issue of allocating VM resources to jobs undergo mapping into the construction graph $G_1 = (N_1, L_1)$. The node set N_1 comprises of every VM and jobs. A set of L_1 edges completely links all the nodes of the graph G_1. Every individual edge (a, g) of the graph G_1 is allocated to the bubblenet and is shown below.

$$\tau_{ag} = \frac{1}{la} \quad (9)$$

where a and g indicates exclusive identification number of a job, and number of a VM, ℓa is the length of the job a. Since the inverse of job length is employed as the bubblenet nature, more importance is provided to shorter jobs over the longer ones.

Allocation of PM resources to VM

Here, the process of allocating resources undergo mapping to a construction graph $G_2 = (N_2, L_2)$. The node set N_2, comprises VM and PMs. L_2 indicates a collection of edges which are completely linked nodes. Every edge (g, j) of the graph G_2 is linked to the bubblenet τ_{gj} and heuristic information η_{gj}, where g isthe identification number of a VM and j is identification number of a PM. It can be represented as

$$\tau_{gj} = \frac{1}{\frac{vm_g}{FM_j}} \quad (10)$$

where vm_g is memory requirements of VM g, and FM_j is available memoryspace of PM j.

PERFORMANCE VALIDATION

Simulation setup: The experimental validation of WOA-TRA technique takes place using CloudSim environment. To analyze the results, a set of methods used for comparative analysis are FFD, EARA and MGGA. A set of 5 data centres were generated with the specifications as provided in [Table 1]. At every data centre, PM fulfils with terms, as provided in [Table 2], were generated. For comparison of the experimental results, a set of 4 kinds of VMs are employed as given in [Table 3]. The intention of executing jobs with various QoS necessitates is to validate the goodness of the WOA-TRA with respect to energy efficiency, number of PM needed, and quality of services. The simulation results of the WOA-TRA technique is investigated under different job count. The experiments were iterated for 25 rounds.

Table 1: Details of Data Centres

Name	Processing Cost	Memory Cost	Storage Cost	Bandwidth Cost	Time Zone
Data Centre 1	3	0.05	0.10	0.10	3.0
Data Centre 2	3.5	0.07	0.10	0.11	5.0
Data Centre 3	4	0.09	0.10	0.07	5.5
Data Centre 4	5	0.10	0.10	0.13	8.0
Data Centre 5	5.25	0.12	0.10	0.15	10.0

Table 2: Details of PMs

PM Type	CPU	Cores	RAM	Storage (TB)	Bandwidth (gbps)
1	1000	4	8	2	10
2	1500	8	16	2	10
3	2000	12	32	2	10
4	3000	20	64	4	10
5	5000	36	64	4	10

Table 3: Details of VMs

VM Type	CPU	Number of Cores (PEs)	RAM	Bandwidth (gbps)
1	500	1	512	1
2	1000	2	1024	2
3	2000	4	2048	4
4	4000	8	4096	8

RESULTS AND DISCUSSION

Fig. 4 illustrates the comparative results of the presented WOA-TRA technique with respect to PMs utilized by various models for fulfilling the computational needs of particular job counts. The presented WOA-TRA model offers better results over all the compared three methods with respect to varying PMs utilized for deploying various jobs. [Fig. 5] portrays the comparative analysis of the total energy consumption takes place by various methods. The total energy utilization of the proposed method is lower than the energy

EDITED BY: Prof. Dr. S. Vaithyasubramanian

IIOAB JOURNAL ISSN: 0976-3104

utilized by compared methods due to the fact that it utilizes few PMs for deploying provided jobs. It can be noted that the FFD model consumed maximum energy utilization and offered poor performance over the compared methods. At the same time, slightly lower and near identical energy consumption is achieved by MGGA and EARA methods. But, the presented WOA-TRA model offers minimum energy consumption over all the compared methods.

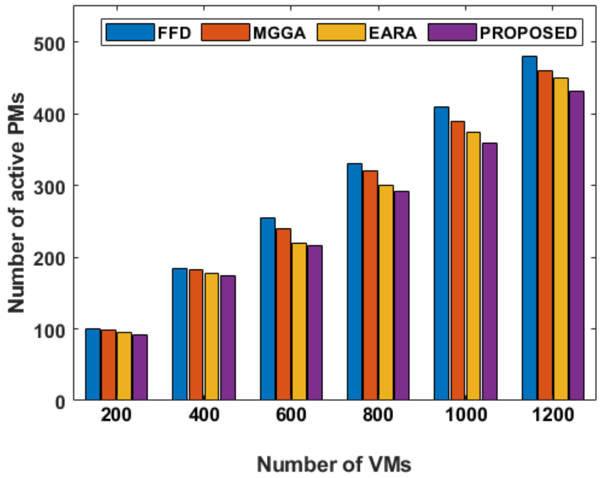

Fig. 4: Results analysis of diverse methods in terms of number of active PMs

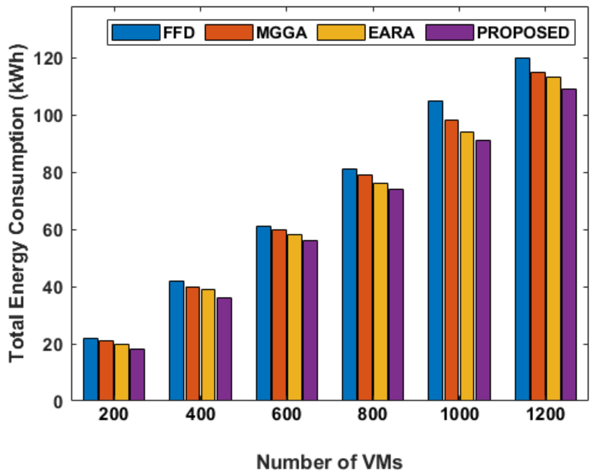

Fig. 5: Results analysis of diverse methods in terms of total energy consumption

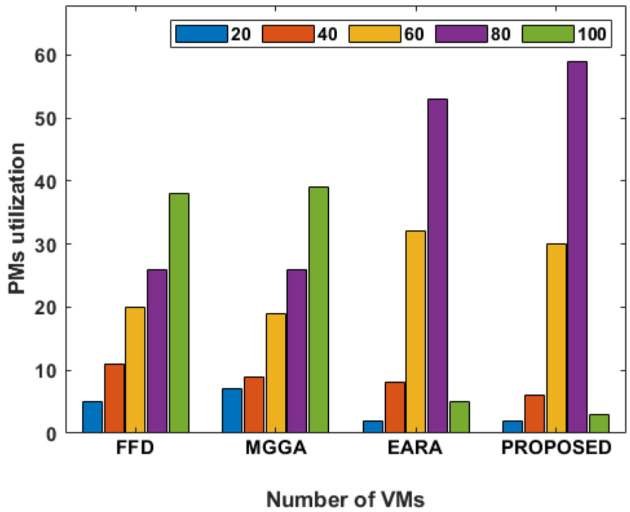

Fig. 6: Results analysis of diverse methods in terms of PMs utilization

Fig. 6 shows the comparison of the PM resource utilized by various methods. The figure clearly stated that the presented WOA-TRA technique has the capability to manage the resources in an effective way. [Fig. 7]

EDITED BY: Prof. Dr. S. Vaithyasubramanian

IIOAB JOURNAL
ISSN: 0976-3104

offers a comparative analysis of different methods with respect to average number of VM migrations. It is observed that the FFD method exhibits lower migrations over all the compared methods. It is also noted that maximum number of migrations are carried out using MGGA technique. Next to that, the EARA and presented WOA-TRA techniques offers moderate number of migrations under varying VMs. Since migration takes place to consolidate PMs, energy conservation can be achieved by switching them to sleep state. It is also noted that around 2 migrations takes place to complete 1200 jobs and it does not have any influence of the system performance. Besides, the WOA-TRA will balance the energy loss by migration through the switching off idle PMs to sleep mode.

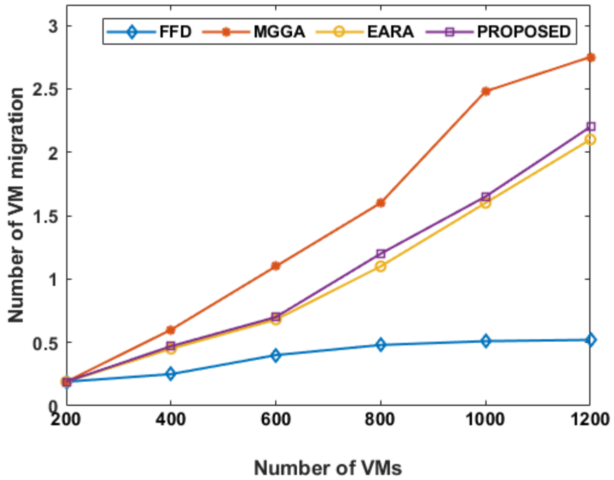

Fig. 7: Results analysis of diverse methods in terms of number of VM migrations

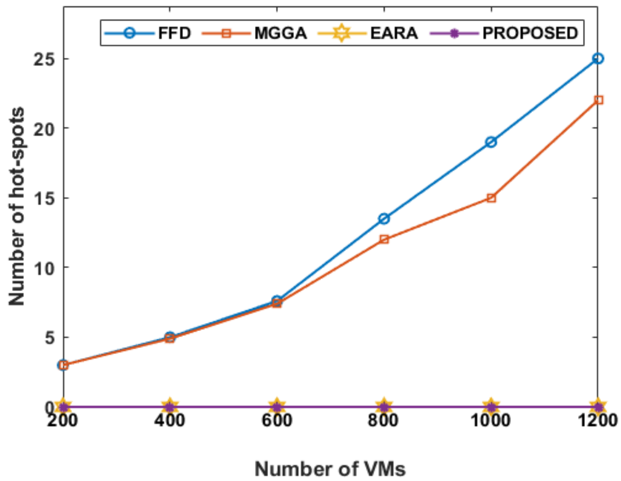

Fig. 8: Results analysis of diverse methods in terms of hot spots.

Fig. 8 displays the comparative results of various methods with respect to the creation of hot spot under varying jobs from 200 to 1200. A PM can be considered as a hot spot when it utilizes the resource up to 100 %. Here, more hot spots are generated by the FFD model due to the fact that it tried to make use of PM to its total capacity. But, the WOA-TRA model does not produce any hot spot which considerably degrades the performance and reliability of PM. Furthermore, the generation of hot spots requires more cooling systems and also raises the possibility of hardware failure. Therefore, WOA-TRA is considered to have more reliability and energy efficiency. [Fig. 9] offered a comparative analysis of diverse methods with respect to total energy utilization by CC platform. The figure indicated that the energy consumption of the presented WOA-TRA model is significantly lower than other methods.

Finally, the computational energy of the presented and compared methods takes place and is shown in Fig. 10. It indicates the total energy utilized usually determined in Watt hours (Wh), to find appropriate resource to every job. It is shown that minimum computation energy is required by the presented model resources for all the jobs.

IIOAB JOURNAL
ISSN: 0976-3104

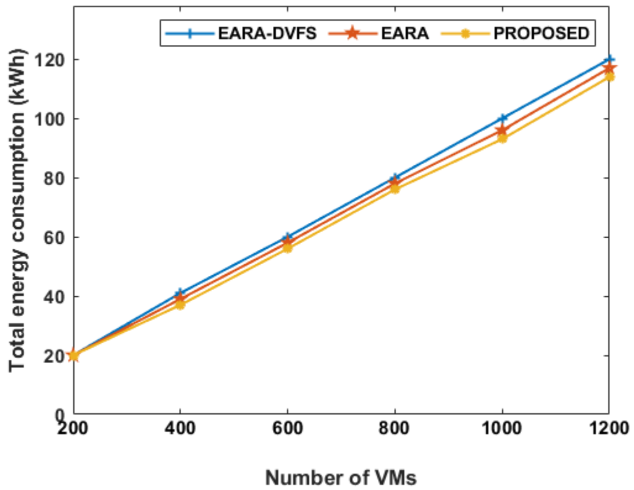

Fig. 9: Results analysis of diverse methods in terms of total energy consumption under varying VMs.

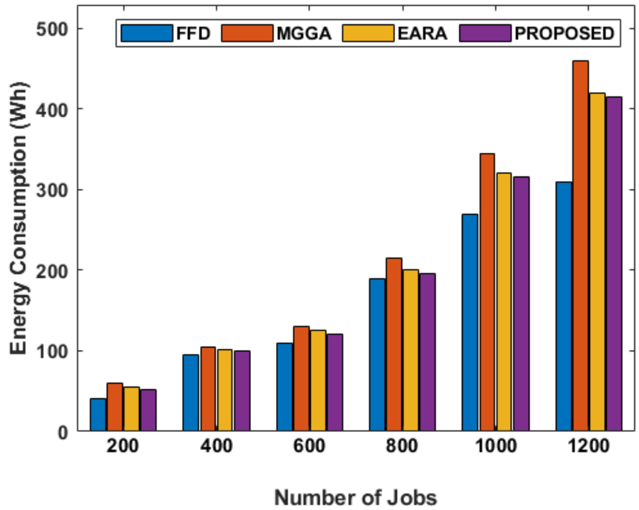

Fig. 10: Results analysis of diverse methods in terms of total energy consumption under varying jobs

This figure shows that the EARA consumes less energy in computation than other methods except FFD which achieves slightly lower computation energy. On observing the experimental results, it can be ensured that the presented model offers maximum performance by effectively allocates the resources in the cloud platform.

CONCLUSION

This paper has introduced a WOA-TRA for resource allocation problem in cloud environment. The WOA is hybridized with tumbling effect which has good exploration ability for function optimization problems and derives a WOA with tumbling effect based energy aware solution called WOA-TRA model. To effectively utilize the energy and QoS requirements, the WOA-TRA technique is utilized in two levels. In the first level, WOA-TRA technique assigns VMs resources to jobs, whereas in second level, WOA-TRA technique assigns PMs resources to VMs. The experimental analysis stated that the presented WOA-TRA technique offered desired QoS and enhanced energy efficiency by effectively utilizes the available resources over the compared methods.

CONFLICT OF INTEREST

There is no conflict of interest.

ACKNOWLEDGEMENTS

None

FINANCIAL DISCLOSURE

None

EDITED BY: Prof. Dr. S. Vaithyasubramanian

REFERENCES

[1] Fox A, Griffith R, Joseph A, Katz R, Konwinski A, Lee G, Patterson D, Rabkin A, Stoica I. [2009] Above the clouds: A berkeley view of cloud computing. Dept. Electrical Eng. and Comput. Sciences, University of California, Berkeley, Rep. UCB/EECS, 28(13):2009.

[2] Kumar A, Kumar R, Sharma A. [2018] Energy Aware Resource Allocation for Clouds Using Two Level Ant Colony Optimization. Computing and Informatics, 37(1):76-108.

[3] Koomey J. [2011] Growth in data center electricity use 2005 to 2010. A report by Analytical Press, completed at the request of The New York Times, 9(20):161.

[4] Kaplan JM, Forrest W, Kindler N. [2008] Revolutionizing Data Center Energy Efficiency. Technical report, McKinsy & Company.

[5] Vogels W. [2008] Beyond Server Consolidation. Queue, 6(1):20–26.

[6] Beloglazov A, Abawajy J, Buyya R. [2012] Energy-Aware Resource Allocation Heuristics for Efficient Management of Data Centers for Cloud Computing. Future Generation Computer Systems, 28(5):755–768

[7] Kinger S, Kumar R, Sharma A. [2014] Prediction Based Proactive Thermal Virtual Machine Scheduling in Green Clouds. The Scientific World Journal, doi: 10.1155/2014/208983.

[8] Quarati A, Clematis A, Galizia A, D'Agostino D. [2013] Hybrid Clouds Brokering: Business Opportunities, QoS and Energy-Saving Issues. Simulation Modeling Practice and Theory, doi: 10.1016/j.simpat.2013.01.004

[9] Lee HM, Jeong YS, Jang HJ. [2014] Performance Analysis Based Resource Allocation for Green Cloud Computing. The Journal of Supercomputing, 69(3):1013–1026.

[10] Raycroft P, Jansen R, Jarus M, Brenner PR. [2014] Performance Bounded Energy Efficient Virtual Machine Allocation in the Global Cloud. Sustainable Computing: Informatics and Systems, 4:1–9.

[11] Feller E, Rilling L, Morin C. [2011] Energy-Aware Ant Colony Based Workload Placement in Clouds. 12th IEEE/ACM International Conference on Grid Computing (GRID), doi: 10.1109/Grid.2011.13.

[12] Gao Y, Guan H, Qi Z, Hou Y, Liu L. [2013] A Multi-Objective Ant Colony System Algorithm for Virtual Machine Placement in Cloud Computing. Journal of Computer and System Sciences, 79:1230–1242.

[13] Nathani A, Chaudhary S, Somani G. [2012] Policy Based Resource Allocation in IaaS Cloud. Future Generation Computer Systems, 28(1):94–103.

[14] Chen H, Cheng AMK, Kuo YW. [2011] Assigning Real-Time Tasks to Heterogeneous Processors by Applying Ant Colony Optimization. Journal of Parallel and Distributed Computing, 71(1):132–142.

[15] Huang CJ, Guan CT, Chen HM, Wang YW, Chang SC, Li CY, Weng CH. [2013] An Adaptive Resource Management Scheme in Cloud Computing. Engineering Applications of Artificial Intelligence, 26(1):382–389.

[16] Garg SK, Yeo CS, Buyya R. [2011] Green Cloud Framework for Improving Carbon Efficiency of Clouds. Euro-Par 2011 Parallel Processing. Lecture Notes in Computer Science, doi: 10.1007/978-3-642-23400-2 45.

[17] Xu J, Fortes JAB. [2010] Multi-Objective Virtual Machine Placement in Virtualized Data Center Environments. IEEE/ACM International Conference on Green Computing and Communications (Green Com), doi: 10.1109/GreenCom-CPSCom.2010.137.

[18] Wu CM, Chang RS, Chan HY. [2014] A Green Energy-Efficient Scheduling Algorithm Using the DVFS Technique for Cloud Datacenters. Future Generation Computer Systems, doi: 10.1016/j.future.2013.06.009.

[19] Mirjalili S, Lewis A. [2016] The whale optimization algorithm. Advances in engineering software, 95:51-67.

THE IIOAB JOURNAL

EDITED BY: Prof. Dr. S. Vaithyasubramanian