Sunfower Whale Optimization Algorithm for Resource Allocation Strategy in Cloud Computing Platform

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Abstract
Cloud computing environment supply the computing resources based on the demand of cloud user requirements. It builds the resource allocation model through distributed computing and virtualization to emphasize the scalability of cloud services. However, to manage the demand of user creates a complex issue in the on-demand resource allocation framework. Therefore, an efective optimization algorithm named Sunfower Whale Optimization Algorithm (SFWOA) is proposed to solve the issues in the resource allocation model. The concept of virtualization helps to execute the tasks based on the availability of resources and reduces the response time. The tasks are allocated to the virtual machine in a distributed manner to balance the workload in cloud. The proposed SFWOA uses the hunting strategy and the foraging behavior of humpback whale along with the peculiar behavior of sunfower to achieve the efective resource allocation. The performance enhancement of the proposed SFWOA is revealed through the performance measures such that the proposed method attained a maximum resource utilization of 0.942 using 20 virtual machines,maximum memory utilization of 0.215, and maximum CPU utilization of 0.269 using 15 virtual machines, and minimum skewness of 0.001 using 25 virtual machines.
Keywords Virtualization · Cloud computing · Sunfower optimization · Whale optimization algorithm · Cloud services

1 Introduction

Cloud computing is an efcient and efective paradigm to maintain and control the applications and computer resources in various organizations especially, medium and small sized business group due to their characteristic features, like self service, rapid elasticity,resource pooling, on-demand, and pay-as-you-go model [**1**]. It characterizes a major phase in computing the resources and shares the cloud power on demand. Based on the virtualization concept, the cloud computing efectively transformed the IT services with the minimal infrastructure requirements. In the recent decades, the cloud paradigm attracted more

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and Research, Bharath University, Chennai, Tamilnadu, India attention in both the industrial and academic communities. Most of the individuals and enterprise systems ofered to outsource vast amount of information to the cloud database rather than maintaining and constructing the local data center. The cloud users accesses diferent types of cloud services that is issued by the public cloud [**2**]. However, the cloud computing model is considered as a new paradigm in the cloud scenario, which allows an efective utilization of resource, energy, and infrastructure with one or more abstraction levels such that the services are made through the computer network or internet. Due to the implication of the availability and higher fexibility with lower cost, the cloud computing receives a great attention in recent years [**3, 4**]. The major benefts involved in using the cloud computing framework are: on-demand service, measured services, resource pooling and broad network accesses [**5**]. In addition to cloud virtualization, the web service technology, and distributed computing provides fexible storages and enhanced performance in the computing scenarios. Based on the virtualization technology, the cloud users can simulate the memory, storage resources, servers, and network in an efective way than original confguration [**6**].

The major advantage of using the resource allocation mechanism [**7, 8**] in the cloud computing is to maximize the utilization of resources and thereby, to decrease the operating cost. The fexibility that observed from the virtualization technology includes the hardware virtualization, like memory, network, storage, and CPU [**9, 10**]. Moreover, in the cloud computing scenario, the primary goal of allocating the resource is to efectively optimize the physical machines (PMs) and balance the workload in the running PMs in a distributed manner to reduce the low-loaded or overloaded resource usage, and bottle neck [**11**]. The resource allocation is termed as the process by which the resources are distributed to the applications of cloud through internet based on the systematic manner.When the cloud resources failed in allocating the resources to the users in an on-demand manner, the services may not be long-lasting. This problem can be solved by permitting the cloud providers to distribute the resource at each module independently. Hence, the resource allocation is focused as a part

in the resource management system such that it shows an efective remarkable factor to allocate the resource efectively and economically[**5**]. Resource allocation is a scheme, which allocates the resource to the Virtual machine (VM) when diferent applications request various resources, like memory and CPU [12]. In the cloud framework, the resource allocation is used to achieve better user satisfaction with less processing time. To minimize the utilization of resources ensures the quality of service in cloud, satisfes the service provider, and increases the throughput. The key idea in the dynamic scheduling scheme is to allocate the request with respect to the time of program implementation [**13**].
In the static method, in addition to cost estimation, the dynamic scheduling model contains two diferent factors, such as decision-making and estimating the system state [**14**].In general, the evolutionary computation (EC) approaches, namely genetic algorithm (GA) is widely used to decrease the energy consumption and to enhance the utilization of resources. However, the GA model modifed with the fuzzy multi-objective system is introduced for virtual machine placement (VMP) in [**15**]. The meta-heuristic methods,such as ant colony optimization (ACO), GA, and particle swarm optimization (PSO) are introduced to provide the optimal solution. The optimization algorithm named Grey Wolf Optimizer (GWO) is introduced in [**5**], which is the inspiration of grey wolves. However,the GMO optimization algorithm uses the hunting behavior and the leadership hierarchy of grey wolves to obtain the optimal solution by considering four diferent categories of the grey wolves, like alpha, beta, delta, and omega in order to simulate the hierarchy of leadership. A new meta-heuristic optimization named Elephant Herding Optimization (EHO) is introduced in [**16**] to solve the optimization problem. The EHO model is inspired based on the herding parameter of elephant groups. The elephants in the clans are updated through the updating operator based on their matriarch and current position. Moreover, the performance is evaluated based on the matching level that exists between the system model and meta-heuristic approach.
This research is focus to model a new framework for resource allocation strategy in the cloud computing scenario using the proposed SFWOA. The cloud model allows the user to process, record, and retrieve the data simultaneously, and the cloud resources, like VM and PM efectively allocate the resources with respect to the minimum cost. Here, the resource allocation is performed to allocate the resources optimally as requested by the users without afecting the system performance. However, the allocation is done based on the minimal cost of VM. The main factors that are considered while allocating the tasks to the VM are the cost, deadline, and runtime. Here, the resource allocation is achieved through the proposed SFWOA, which is the integration of Sunfower Optimization Algorithm (SFO)and Whale Optimization Algorithm (WOA), respectively. The major contribution of this research is explained as follows:

- The resource allocation is based on the proposed SFWOA, which is the integration of SFO and WOA optimizations, which inherits the parametric features from WOA and SFO to enhance the performance of resource allocation strategy. The proposed algorithm efectively allocates the task to VM by con-

sidering the minimal ftness value.

The rest of this paper is organized as follows: Sect. **2** explains the literature review of the existing resource allocation techniques and Sect. **3** discusses the cloud model. Section 4 elaborates the proposed optimization algorithm for the resource allocation framework in cloud and Sect. **5** explains the results and performance enhancement of the proposed approach. Finally, Sect. **6** concludes the paper.

2 Motivation

In this section, various existing resource allocation methods along with their merits and demerits are explained, which helps the researcher to develop a new resource allocation mechanism to increase the performance of system.

2.1 Literature Survey

Various existing allocation methods are reviewed in this section. Lei Jiao et al. [14] developed a regularization based approach for designing the dynamic algorithms with and without using the prediction scheme. It efectively solved the coupled decisions, and reconfguration induced by considering the workload of previous time schedule and resource price of recent time slot. It generated an efective solution for the operating prices and dynamic workloads. However, this method reduced the cost in resource allocation, but failed to minimize the error rate. Fan-Hsun Tseng et al. [17] introduced a Genetic algorithm (GA) for dynamically forecasting the consumption of energy and the utilization of resources incloud. This method considered the memory and CPU utilization with the PM and VM. Moreover, it forecasted the resource to be utilized for the successive time slot with respect to the historical data at previous time slot. This method minimized the energy consumption and maximizes the memory and CPU utilization, but failed to verify the prediction accuracy. Li-Der Chou et al. [18] developed a dynamic power saving resource allocation(DPRA) using the particle swarm optimization approach to enhance the energy-efciencyin cloud. The resource utilization of PM was forecasted by the least square regression model. It failed to consider the evolution iteration and the selection time to increase the performance of data center in cloud. It was applicable for the topology structure with various networking capability. Jyotiska Nath Khasnabish et al. [19] developed a Tier centric Business Impact and Cost Analysis (T-BICA) for the resource allocation strategy in the multi-tier cloud system. This approach monitored the resource utilization in individual tiers and allocated the resources to the specifc tiers such that he load may exceed the threshold value. This method utilized same resource pool capacity for the number of iteration in the business service. However, the performance of this model was not efective.Wanyuan Wang et al. [20] introduced a decentralized multiagent (MA)

based VM allocation scheme in cloud to reduce the energy consumption. It used an auction-based model to decide the allocation of VM to the respective PM. The negotiation-based model was developed to exchange the tasks for saving the energy cost. It failed to address the bi-objectives and energy cost simultaneously. Siqian Gong et al. [21] introduced an adaptive control model to allocate the resources in cloud based on the resource demands and request workloads. The multiple resources were efectively allocated to multiple services using the multivariable control based on the fuctuating requests. This method satisfed the service request and increased the resource utilization, but failed to evaluate the efciency. Wei Wei et al. [9] developed an Imperfect information dynamic stackelberg game-based resource allocation model in cloud. It supported the synchronous allocation in both the multi-service resources and providers. It reduced the transaction price and guaranteed the service providers' proft. It failed to optimize the system in running more efciently based on the adjustable parameter requirements. Xi Liu et al. [22] introduced a swarm optimization algorithm for allocating the resources in cloud more efectively. It efectively utilized the searching behavior and enhanced the performance of algorithm by balancing the exploration and exploitation parameter. This method maximized the resource utilization,but failed to consider the scalability.

2.2 Challenges

Some of the challenges associated with the existing resource allocation methods are explained in this section.

- The major challenge faced by the resource allocation strategy in cloud is elasticity.However, elasticity indicates the extent of handling the resource requirements dynamically. Resources in the cloud environment are high demand as it increases over time such that the cloud must detect the size of requirement and to allocate the required resources in order to meet the demand [23].

- In the multi-tier cloud system, the resource allocation issues in the service provisioning results poses a challenging task due to various factors, like the request for joint allocation, need for service demands, and reconfguration cost [14].

- The resource allocation scheme has a key impact in the feld of Information and communication technology (ICT) as the user has diferent characteristics. To allocate the ICT resource, such as storage device, and processing unit, faces a challenging task due to the dynamic fexibility and availability of resources [16].

- The management of resources in the cloud computing framework is associated with the fuctuating workload, which poses a major issue to the elasticity of cloud [24].

- In cloud model, the services are owned based on the constraints of customers in the computing model and hence to optimally enable the resource consumption is a major challenge [25].
- To manage and control diferent applications in the cloud, data center poses a greatchallenge in the on-demand allocation in workload and resource provisioning. Moreover, the energy usage poses a complex issue in the computing applications.

3 Cloud Model

The cloud computing framework [26] allows the cloud users to store, retrieve, and process the information simultaneously since the cloud handles quite large quantity of data per second. The cloud resources, like PM and VM executes the task based on the request of user. VM migration aims to dynamically respond to the user request in order to provide cloud services. The resource allocation technology in cloud efectively allocates the resources to VM in order to perform the deserved task. The performance degradation and cloud operation makes the cloud model more inefcient hence, it is required to design the resource allocation strategy more careful. Moreover, each task has its own deadline and runtime. Based on the minimum cost factor, the resource allocator allocates the task to the available VM. Hence, the resource allocator gets the updated status of VM to allocate the task for execution. The resource allocation in cloud model is shown in Fig. 1.

4 Resource Allocation in Cloud Based on the Proposed Sunfower Whale Optimization Algorithm

Due to the need for service demands and reconfguration cost, the resource allocation in cloud provisioning services poses a challenging task. Hence, a new computing framework is introduced in the cloud environment in order to achieve efective resource allocation. The resource allocation scheme in the cloud computing model is achieved using the proposed SFWOA based on which the task selected for execution is done. The proposed SFWOA is used to efciently allocate the resources for the execution of each task. The resource allocation based on the proposed optimization algorithm increases the efciency of cloud model.Since the resources are dispersed in vast surface, resource allocation is highly efective in the cloud environment. PM monitors and controls the VM such that each VM has its own CPU memory with MIPS speed. The resource allocation model contains diferent cloud providers that are linked to the VM, private, and external. Let us assume two PM represented as, P1 and P2, and fve VM as V1, V2, V3, V4, and V5, respectively. The task assigned by the users is executed using the VM, which is expressed as V = V1, V2, V3, V4,

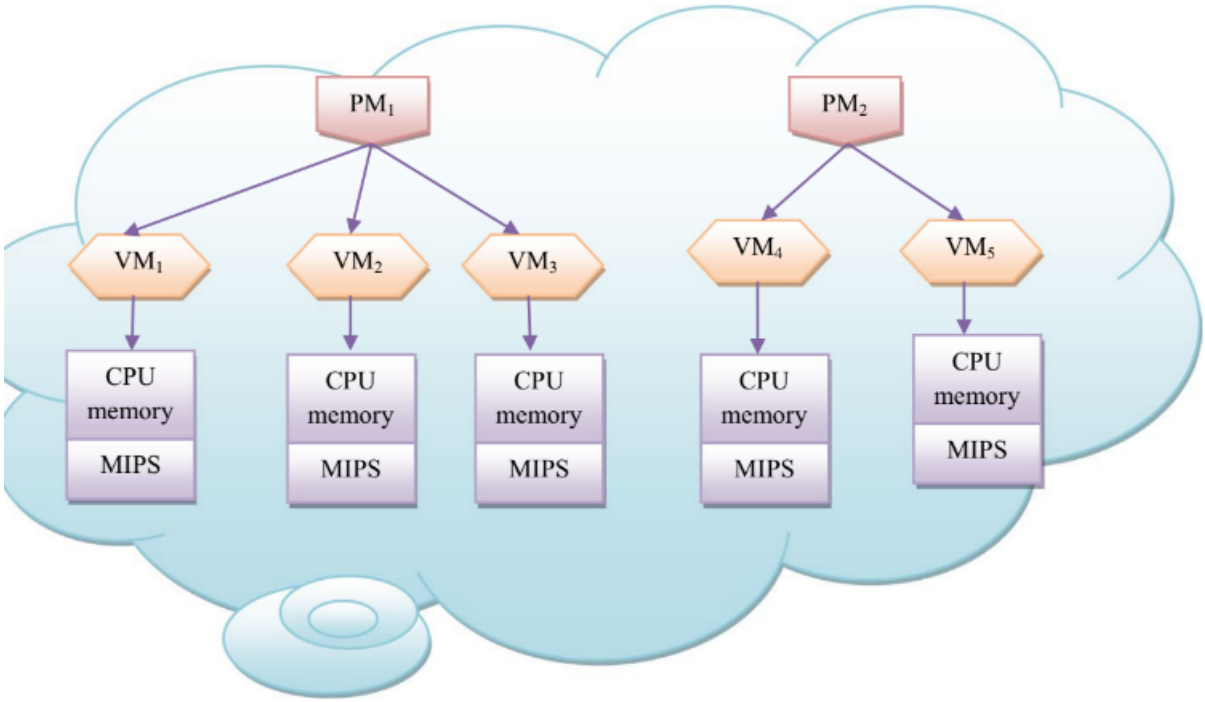

Figure 1: Resource allocation in cloud model

V5. The applications that are accepted from the user are specifed as, A. Each application holds dif- ferent tasks and is denoted as, s.

4.1 Task Flow

Let us consider the task s that is assigned to the VM based on the availability of resources.Here, three tasks are considered as s1,s2,s3and the deadline for these tasks are represented as D1, D2, D3 with the start time of S1, S2, S3and the runtime of R1, R2, R3 ,respectively. The task fow for three diferent tasks along with their deadline, start time,and run time is specifed in Table 1. The tasks are allocated to the VM to perform the computation process.when the cloud receives the application for processing, the tasks s1, s2, and s3 are assigned to the VM using the proposed SFWOA. However, the allocation is done based on the minimal cost of VM. The main factors that are considered while allocating the tasks to the VM are the cost, deadline, and the runtime. The cloud framework consistsof both the external and private clouds. The tasks are mostly allocated to the VM in private cloud as the resources in private cloud do not inquire any additional cost. The task having minimum cost is assigned to the VM in cloud. When a task arrives in the cloud to progress, the proposed optimization algorithm verifes their runtime and deadline of the task, and the task with the minimum cost is assigned to the VM to efectively perform the resource allocation. Let us consider three diferent application as T1,T2, and T3 and each of these application have diferent tasks to execute. Various tasks along with their dead line, runtime, and start time are specifed in Table 2. For each task s,the deadline, and the runtime used to execute the tasks at each application

task	s1	s2
deadline	D1	D2
Runtime	R1	R2
start time	S1	S2

T is clearly