International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

An Optimization-Based Approach for Task Scheduling to Enhance Resource Utilization in Cloud Computing

N. Manish Madhukar Dakhore[1], Anil Srivastava[2], Dr. Shweta Saxena[3], Dr. KDV Prasad[4], Dr. Nandini Kulkarni[5], Dr. Bajarang Prasad Mishra[6]

Submitted: 20/04/2023 **Revised**: 14/06/2023 **Accepted**: 26/06/2023

Abstract: In cloud computing, job scheduling is closely related to processing costs and resource use. To ensure the best work completion, a variety of optimal task scheduling techniques make good use of these parameters. Task scheduling especially increases the cloud-based system's source utilization and processing costs. In order to provide optimal scheduling, numerous optimization methodologies are used to enhance task scheduling performance. Several heuristic scheduling techniques, including Min-Min, Max-Min, and Heterogeneous Earliest Finish Time (HEFT) algorithms, have been developed and created for cloud-based systems. Several meta-heuristic task scheduling methods that produce ideal schedules have also been created, including the scheduling technique based on the Particle Swarm Optimization (PSO), and Ant Colony Optimization (ACO). Task scheduling is a plan for controlling the situation in which work must be done. It is providing resources to appropriate activities; when tasks are introduced with an eye towards their completion, it appears in the NP-hard crisis feature due to a large number of solution explorations and accepts the longest possible time for determining the best outcomes. In a cloud environment, results are produced at their best through resource maintenance processes. Task scheduling solves the problem where resources must be divided among numerous jobs to maximize resource utilization and shorten operating times. Scheduling approaches must be effective in order to achieve higher utilization, and they believe that the network's overall load should be balanced, disturbances should be managed, errors should be tolerated, and the execution time should be reduced.

Keywords*: *HEFT, Resource Utilization, PSO, ACO

1. Introduction

In order to enable a cost-effective, scalable, and flexible exploitation of heterogeneous resources, cloud computing is a subscription-based on-demand service that provides software, infrastructure, and platform-type services. It has been linked to Grid computing, distributed computing, and utility computing to provide effective virtualization and reflection with shrinking space. The way cloud computing works is described as assigning jobs to a set of resources made up of numerous computers connected by the internet and offering a wide range of services, including power, storage, and a variety of software services, depending on the task at hand [1]. Effective task-scheduling algorithms can manage these jobs to prevent resource overload, enhance resource utilization, shorten response times, and increase throughput. Task scheduling's goals are to maintain the system's consistency, improve speed, build a fault-tolerant system, and provide a future deviation in the system, such as protection while sacrificing customer time and resources for new activities.

1Assistant Professor, Mechanical Engineering Department Yeshwantrao Chavan college of Engineering, Nagpur, Maharashtra, India - 440024.
manish.dakhore@gmail.com
Orchid id: 0000-0003-0601-6997
2Assistant Professor College Of Commerce, Nande Pune Savitribai Phule Pune University
anilsri.04@gmail.com
3Assistant Professor Amity Business School of Management Amity University MP Gwalior India
er.saxenashweta15@gmail.com
4Assistant Professor, Symbiosis Institute of Business Management, Telangana, Hyderabad;
kdv.prasad@sibmhyd.edu.in
Orcid: 0000-0001-9921-476X
5Deputy Director Symbiosis School of Planning Architecture and Design Symbiosis International University, Nagpur. India.
deputydirector@sspad.edu.in
Orchid id: 0000-0001-9575-9113
6Associate Professor JSS Academy of Technical Education, Noida
bpmishra@jssaten.ac.in
0000-0002-2369-4266

Distributed and centralized scheduling are the two categories into which cloud computing job scheduling is split. In distributed scheduling, the tasks are distributed across a range of resources and placed in several locations [2]. The jobs are distributed across numerous resources and centralized scheduled with the least amount of complexity. The distributed scheduling process is further divided into three categories: hybrid, heuristic, and meta-heuristic. Heuristic scheduling comes in two flavours: static and dynamic, and there are four flavors of hybrid scheduling: cost-based, energy-based, efficiency-based, and Quality of Service (QoS) based. There are two categories of meta-heuristic scheduling: swarm and bio-inspired.

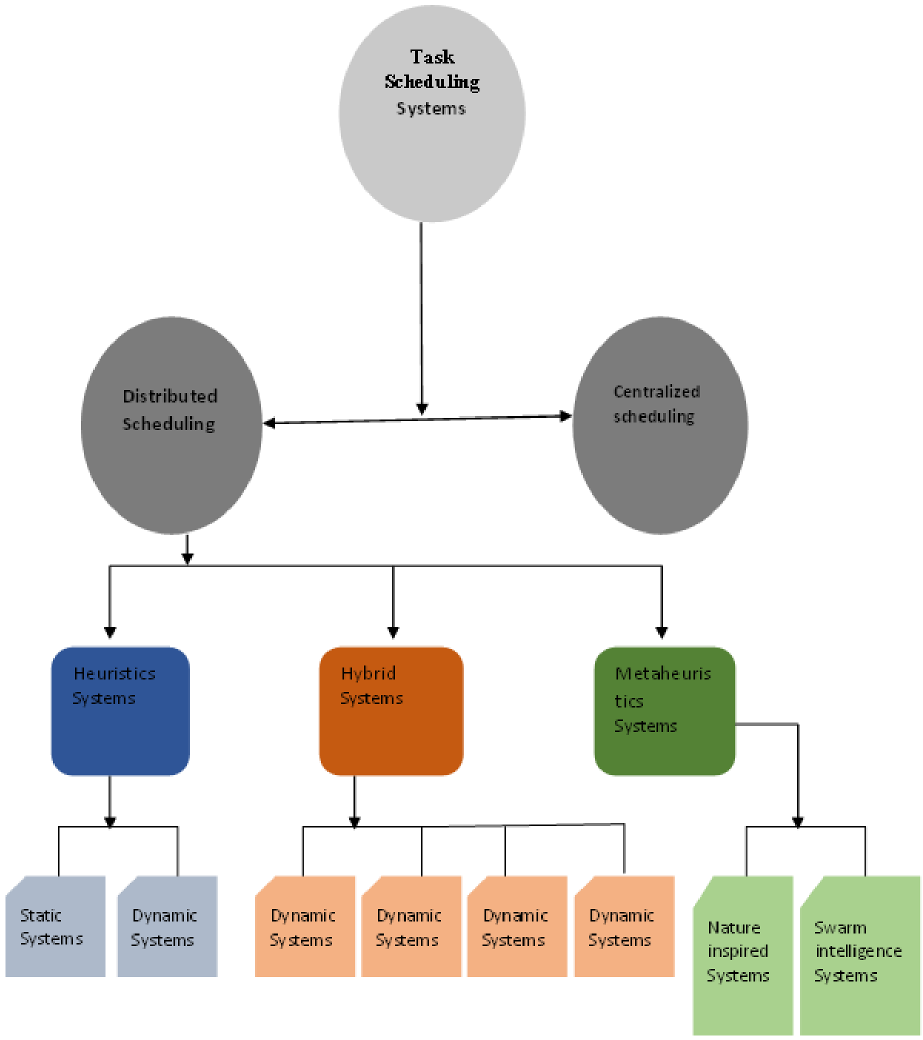

Fig 1: Task Scheduling Algorithms Taxonomy.

An ideal object is chosen from a large number of existing objects using the optimization process (depending on a few specific conditions). It demonstrates how single-objective and multi-objective functions with a few constraints can be used to determine the object's maximum and minimum values. It is selection criteria for minimum and maximum values rather than a problem-solving approach [3]. A technique for making anything as totally ideal, practical, or competent as is likely is known as optimization. By analytically selecting input values within a specific range and evaluating the function, an optimization strategy minimizes or maximizes an objective function. Many fields of functional mathematics are included in the specialized optimization review and methods for all deterrence. Finding "optimal attainable" values for the objective function within a set of constraints is the essence of optimization [4].

1.2. The optimization's major elements include several:

Objective element: It is a mixture of multiple phrases that describes the various traits or qualities of items and evaluates to provide the minimum or maximum values. Here, one or more objectives are used to solve an optimization problem where object compatibility is absent. One term or item may be different from another, and using weight factors can further make this possible [5].

Variables: A significant group of unknowns is referred to as a variable. The variables have been used to describe restrictions and objective utility. Devise Assuring precise serviceability and other necessities, variables cannot be chosen arbitrarily.

Constraints: The requirements that allow the unknowns to achieve the confidence values without involving others are known as constraints. Prior to now, the devise variables, constraints, and goals have been chosen and merged to form the goal function of the optimization problem.

The evolution of organizing the jobs for auxiliary use in diverse applications is task scheduling and optimization. The jobs are distributed across several machines according to their equivalents, making it easy to use them for vigorous applications. Nature-Inspired Algorithms can be thought of as a way to arrange tasks and news amongst people or organizations all over the world via the Internet without worrying about the message being intercepted and without losing the integrity of the original information [6]. On the other side, protecting information's intellectual property rights has received a lot of attention. The interest in exploratory task scheduling methods has been greatly stoked by this in recent years. Only the nodes with shorter execution times do the tasks first when compared to the nodes with greater execution times, according to nature-inspired techniques. Also, a third party cannot take part in the task scheduling but can observe that jobs have been finished moving from one node to another. However, nodes or virtual machines have been selected using a nature-inspired algorithm based on network traffic, cost compromise, fittest value, and faster execution times.

2. Review of the literature

Due to the vast scale of the network of computers and storage devices, task scheduling is one of the fundamental problems in cloud computing. In order to maximize the use of cloud devices and storage while minimizing costs, task scheduling directly depends on the CPU power, storage capacity, and source bandwidth. Resources, data, policies, instructions, and substitute structures are frequently affixed to maintenance agreements, communication, and transfer services offering flexible, reliable, and least expensive heterogeneous environments over the cloud computing environment [7]. Task scheduling in cloud computing can be used to take full advantage of the vast communication network and memory available. For the best task scheduling over networks, several researchers have created a variety of nature-inspired metaheuristics optimization algorithms, such as the Bacteria Foraging (BF) algorithm, Ant Colony Optimization (ACO), Genetic Algorithm (GA), and Harris Hawk Optimization (HHO).

Effective and trustworthy task scheduling makes good use of both the processing power of resources and the cloud storage's memory with the least amount of money spent. Because they produce minimal computation time with load balancing and maximum throughput, the superior task scheduling algorithms have boosted the efficiency of cloud computing. Task scheduling is specifically employed to preserve resource strength, boost energy efficiency, create reliable resources, and produce future resource excursions like resource protection and consumption [8]. Using the cloud network, load balancing is used to manage task scheduling. Under both plans, the processing is done efficiently without subjecting the systems to an overburden of work. Prior to being distributed efficiently among systems, the tasks are first introduced to the cloud using an optimal task scheduling technique. Due to the task scheduling approach's intensive use of the CPU, storage, and resources, the cost of processing the tasks is a highly important consideration [9].

The cloud is an individual competent strategy that offers works through a network, and its relevance is expanding as networks start to take off. Many users are served by a variety of cloud vendors for economical and productive communication. Using resources is accomplished by efficiently optimizing task scheduling. Resources for cloud information interior are distributed based on virtual device configuration and concurrent resource requests [10]. The virtual machines are effectively utilized for efficient cost management to enhance job scheduling performance. One of the bio-inspired methods for effectively performing work scheduling among Virtual Machines (VMs) is the hybrid combination of the Cuckoo Optimization Algorithm (COA) and Particle Swarm Optimization (PSO). To improve the task scheduling strategy, a hybrid cuckoo PSO is developed, and outputs are assessed based on task scheduling time and cost [11].

Based on the scalability and price of resource distribution dynamically, the best job scheduling has improved cloud computing efficiency. To improve the exploration and exploitation capability of the search space and produce the best solution, oppositional logic is also integrated with optimization techniques. As a result, Opposition Based Learning (OBL) and Line Optimization Algorithm (LOA) are combined to enable a task schedule that is both efficient and affordable in a heterogeneous CloudSim environment [12]. The oppositional lion optimization technique is used to optimize the work scheduling strategy and make it more efficient. For improving the exploration criteria of optimization in various forward and backward orientations, the oppositional strategy is introduced. Employing the CloudSim tool enhances the searching ability of optimization to find the best solution. When compared to earlier job scheduling techniques like PSO and GA approaches, the lion optimization performs better [13].

With the aid of a service level agreement, task scheduling is particularly suited for cloud computing, where a number of businesses are using remote location data and performing data processing in a dispersed manner. In this case, the optimal virtual devices for job scheduling are determined by combining a genetic algorithm with bacterial foraging optimization. These algorithms enable job scheduling that is both economical and environmentally friendly in order to reduce waste. Calculations of the algorithm's convergence speed, mobility, and variety are made and contrasted with those of competing approaches [14].

Another optimization method for giving the data the best chance of being attacked is the Dragonfly Optimization Algorithm (DOA). While choosing nodes to minimize network maintenance costs, energy cost, keys, and speed are important considerations [15-17]. The network's structure is constantly changing as nodes move in a multidimensional environment with dynamic velocity. The DOA is applied to this dynamic environment in order to choose the nodes, and the results show that it is stronger than PSO and earlier systems [18-20].

A Black Widow Optimization Algorithm (BWOA) for node selection is created for a multidimensional environment to increase the security of distributed data management systems. This approach considers the viewpoint of the attacker, where the selection of nodes can be carried out in the best possible way by applying BWOA to an objective function that combines stability, mobility, energy, and cost. The BWOA assesses network traffic results, taking aim at ACO and other schemes' efficiency and complexity [21-23].

3. The Objective of the Research

From the list of research motivations above, the following particular objectives have been chosen for study.

(1) To examine different task scheduling methods across all cloud computing environment frameworks.

(2) To create a job scheduling optimization technique for the cloud computing environment.

(3) To assess an algorithm's effectiveness by contrasting it with other researchers' algorithms.

(4) To improve system performance by making use of the resources.

4. The Proposed Work:

The effectiveness of the Chaos BSA and EHOTS methods is analysed to locate the best method for scheduling client jobs in a cloud setting. In order to find the best schedule for client work, we apply Chaos BSA and EHOTS (independently) to the FMO multi-objective optimization function. Results from Chaos BSA and EHOTS have been compared to those of PSO and ALO, as well as other methods, in terms of total cost, for both small and large numbers of tasks and iterations.

The chaos BSA for task scheduling undergoes the following processes.

Step 1: A connection needs to be made between client tasks and birds.

Step 2: We set the starting points for the bird locations, the explorable dimensions, the number of iterations, and the constants. The chaotic equation is used to seed the initial bird population.

Step 3: The optimal solution exploration technique then uses the position data of each bird to calculate its fitness score. The present ideal solution is to choose the bird with the lowest fitness value.

Step 4: The minimum objective optimization function F_{mo} is represented as:

$F_{mo} = minimum\ \{w_1 F_{fc} + w_2 F_{sc} + w_3 F_{tc}\}$

Step 5: The birds' positions are adjusted.

Step 6: All possible repetitions of steps 3 and 4 are carried out.

Step 7: The solution will be updated with the position information of the final creator bird; this information will be used to determine the most efficient method of doing tasks in the cloud.

The EHOTS performs the following steps.

Step 1: Initially, the mapping between user tasks and elephants is to be done.

Step 2: The elephant position, searching dimension, elephant populations, number of repetitions, and constant`s values provide initial values.

Step 3: All the elephant`s fitness values are calculated according to the elephant`s position information in the optimal solution-searching process. The elephant with minimum fitness value is denoted as the current best solution.

Step 4: The entire elephants are updating their positions.

Step 5: Step 3 to step 4 is continued for all repetitions.

Step 6: The position information about the last leader elephant will be added to the solution, which is used for generating the best execution scheme of tasks in the cloud computing environment.

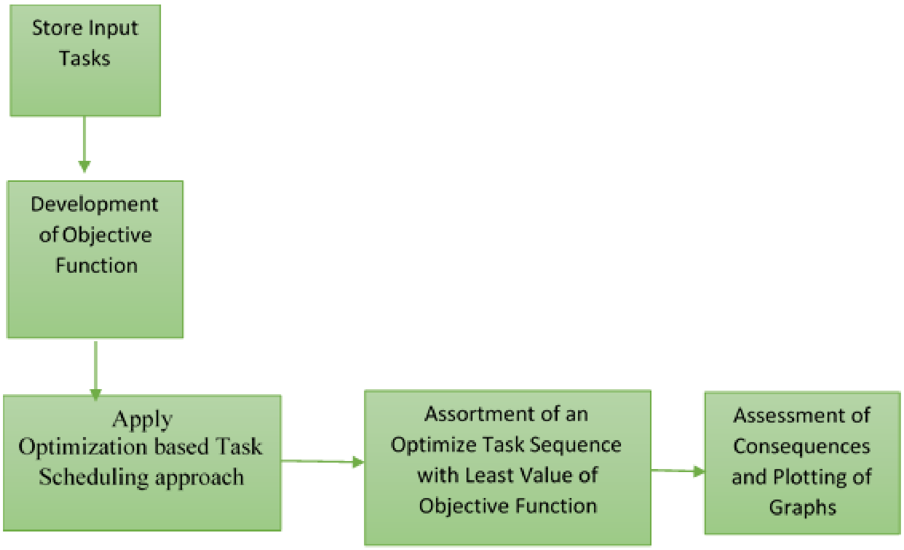

Fig II: The Proposed Block Diagram.

The minimum objective optimization function F_{mo} for chaos BSA is represented as:

$$F_{mo} = minimum\ \{w_1 F_{fc} + w_2 F_{sc} + w_3 F_{tc}\} \quad (1)$$

Where, F_{fc} is first objective function, F_{sc} is second objective function and F_{tc} is third objective function. Moreover, w_1, w_2, w_3 are respective weight factors.

Total optimization function for a set of goals in EHOTS approach, when the attribute functions FPE and FLE are combined with a small number of weight factor coefficients, F_{me} is clearly demonstrated.

$$F_{me} = minimum\ \{w_1 F_{p1} + w_2 F_{p2}\} \quad (2)$$

Where, F_{p1} is first attribute processing expense function, F_{p2} is second attribute processing expense function and w_1, w_2 are respective weight factors. The minimum objective optimization functions is calculated for different task range of 500 to 1500 and compared with existing approach. The consequences are compared and summarized below in Table I.

Table I: The value of Optimization Function for 500 Tasks.

Number of Iterations	PSO	ALO	EHOTS	Chaos BSA
20	0.285	0.287	0.274	0.251
40	0.286	0.321	0.285	0.259

60	0.284	0.286	0.324	0.318
80	0.287	0.328	0.329	0.316
100	0.326	0.319	0.326	0.324

According to the data presented in Figure III and Table I, PSO achieves 14% better outcomes than ACO, whereas ALO provides 12% better outcomes than PSO. By comparison to ALO, the EHOTS produces 11% higher yields, and compared to PSO, it yields 12% higher yields.

For modest numbers of activities (500 tasks), the Chaos BSA produces 13% higher efficiency compared to EHOTS, 15% superior efficiency compared to ALO, and 19% superior efficiency compared to PSO based on overall cost.

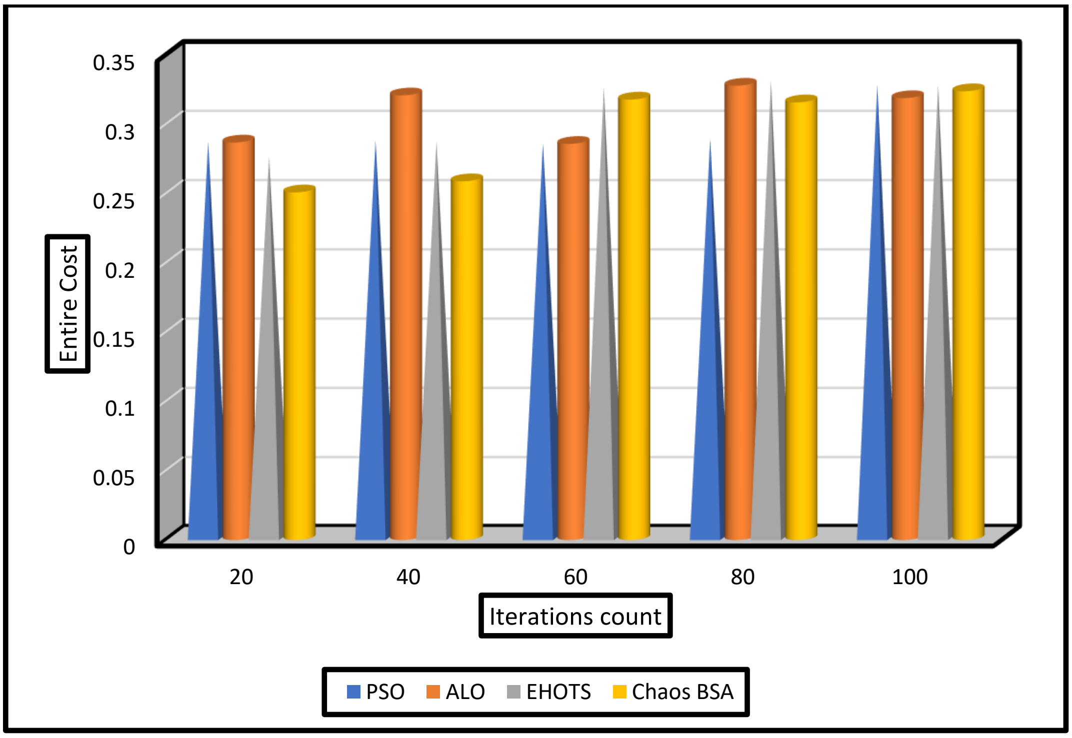

Fig III: The value of optimization function for 500 Tasks.

Table II: The value of Optimization Function for 1000 Tasks.

Number of Iterations	PSO	ALO	EHOTS	Chaos BSA
20	0.3326	0.2811	0.2798	0.2718
40	0.3313	0.3063	0.2536	0.2453
60	0.2926	0.2614	0.2467	0.2347
80	0.2912	0.2784	0.2614	0.2458
100	0.2897	0.3125	0.2798	0.2578

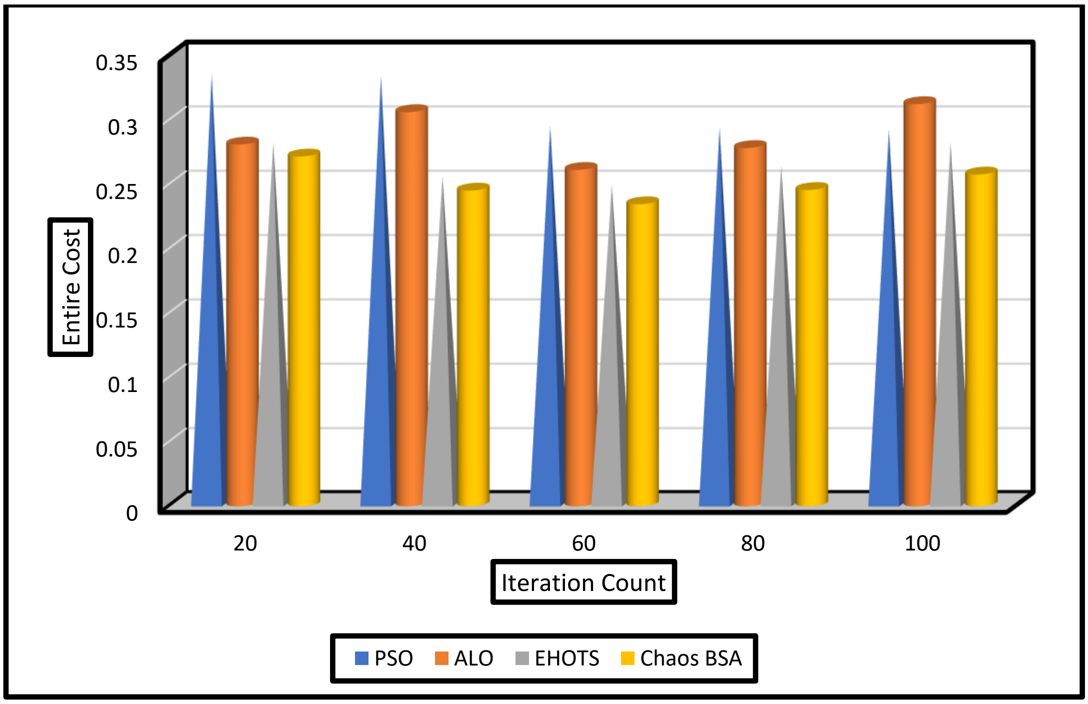

Fig IV: The value of Optimization Function for 1000 Tasks.

According to the findings (shown in Figure IV and Table III), the PSO achieves outcomes that are 16% more favourable than those generated by the ACO, while the ALO provides outcomes that are 8% more favourable than those generated by the PSO. When compared to ALO, the EHOTS produces outputs that are 8% higher, and when compared to PSO, those outputs are 13% higher. In terms of the overall cost for a large number of tasks (1000 tasks), the Chaos BSA generates 11% superior efficiency in comparison to EHOTS, 16% superior efficiency in comparison to ALO, and 21% superior efficiency in comparison to PSO. All of these comparisons are made on the basis of the number of iterations.

Table III: The value of Optimization Function for 1000 Tasks.

Number of Iterations	PSO	ALO	EHOTS	Chaos BSA
20	0.293	0.275	0.264	0.241
40	0.291	0.272	0.263	0.238
60	0.283	0.274	0.261	0.237
80	0.284	0.261	0.257	0.228
100	0.276	0.253	0.258	0.215

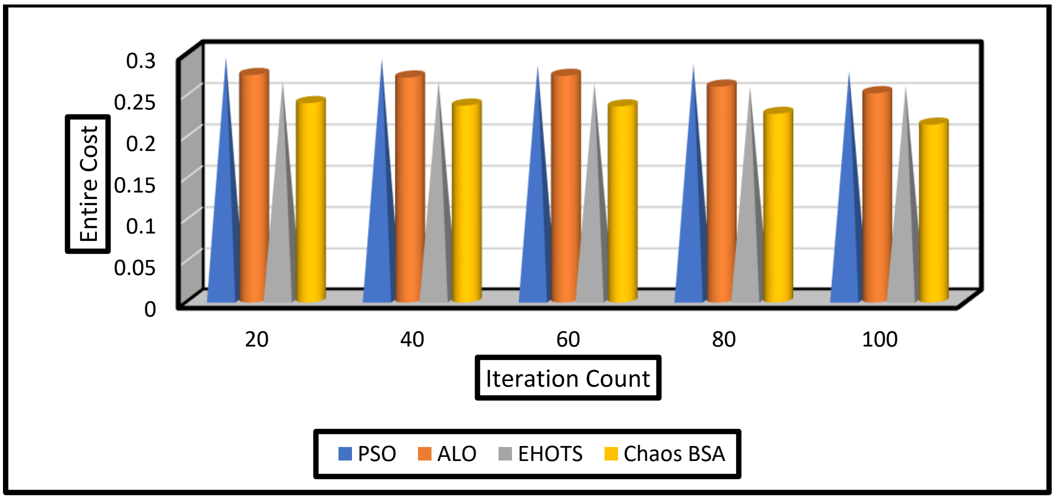

Fig V: The value of Optimization Function for 1000 Tasks.

Figure V and Table III show that compared to PSO, ALO yields 14% better results. When compared to ALO, the EHOTS produces 11% better results, and when compared to PSO, the EHOTS produces 14% better results. For high numbers of jobs (1500 tasks), the Chaos BSA generates 15% better efficiency than EHOTS, 15% better efficiency than ALO, and 24% better efficiency than PSO in terms of overall cost.

5 Conclusion:

When using cloud computing, the scheduling of jobs has a significant impact on the amount of computer power and other resources that are used. Many studies have used these criteria to find the most effective way to partition the work that needs to be done. The work scheduling feature of a cloud-based system can make the use of its resources and the overall cost of the process look noticeably better. Several scholars have collaborated to develop and put into practise a variety of optimization algorithms with the goal of improving cloud-based job scheduling. In this work, we generate the most optimal scheduling of users' tasks by employing a combination of two methods: the Elephant Herding Optimization based Task Scheduling (EHOTS) method and the Chaos Bird Swarm Algorithm (Chaos BSA) method. Our objective is to maximise the utilisation of cloud resources while minimising the amount of money spent on processing. The simulation is carried out with the help of the tool MATLAB 2019a, and the findings indicate that Chaos BSA performs better than EHOTS, ALO, and PSO in terms of the overall cost. This is the case regardless of the number of tasks or iterations involved.

It is possible that in the not too distant future, researchers may be able to organise work according to audio and visual data. It's possible that one day we'll be able to improve the Strength of Chaos BSA and EHOTS by incorporating concepts like entropy and multidimensional chaotic maps. There is room for development in the capability of the task to be scheduled.

Conflict of Interests:

The authors declare that there is no conflict of interests regarding the publication of this paper.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

References:

[1] C. Rajan, K. Geetha, C. Rasi Priya and R. Sasikala, “Investigation on Bio- Inspired Population-Based Metaheuristic Algorithms for Optimization Problems in Ad Hoc Networks”, World Academy of Science, Engineering and Technology International Journal of Computer and Information Engineering, Vol. 9, No. 3, pp-1-8, 2015.

[2] Chia Wei Tseng, Fan Hsun Tseng, Yao Tsung Yang, Chien Chang Liu and Li Der Chou, “Task Scheduling for Edge Computing with Agile VNFs On-Demand Service Model toward 5G and Beyond”, Wireless Communications and Mobile Computing, Hindawi, pp-1-13, 2018.

[3] Davneet Singh Chawla and Kanwalvir Singh Dhindsa, “A Load Balancing based Improved Task Scheduling Algorithm in Cloud Computing”, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Vol. 5, Issue 9, pp-161-170, 2017.

[4] Davinder Kaur, and Sarpreet Singh, “An Efficient Job Scheduling Algorithm using Min-Min and Ant Colony Concept for Grid Computing”, International Journal of Engineering and Computer Science, Volume 03, Issue 07, pp-6943-6949, 2014.

[5] Davinder Kaur, and Sarpreet Singh, “An Improved min - min Algorithm for Job Scheduling using Ant Colony Optimization”, International Journal of Computer

Science and Mobile Computing, IJCSMC, Vol. 3, Issue. 5, pp-552–556, 2014.
[6] Dezhong Yao, Chen Yu, Hai Jin and Jiehan Zhou, “Energy Efficient Task Scheduling in Mobile Cloud Computing”, 10th International Conference on Network and Parallel Computing (NPC), HAL, Guiyang, China, Springer, Lecture Notes in Computer Science, pp-344-355, 2013.
[7] Elhossiny Ibrahim, Nirmeen A. El-Bahnasawy, and Fatma Omara, “Dynamic Task Scheduling in Cloud Computing Based on the Availability Level of Resources” International Journal of Grid and Distributed Computing Vol. 10, No. 8, pp.21-36, 2017. (http://dx.doi.org/10.14257/ijgdc.2017.10.8.03)
[8] Elhossiny Ibrahim, Nirmeen A El-Bahnasawy and Fatma A Omara, “Job Scheduling based on Harmonization between the Requested and Available Processing Power in the Cloud Computing Environment”, Journal of Information Technology & Software Engineering, Vol. 5, Issue 3, pp-1-4, 2015.
[9] Pradeep K, Ali LJ, Gobalakrishnan N, Raman CJ, Manikandan N (2022) CWOA: Hybrid approach for task scheduling in cloud environment. Comput J 65:1860–1873.
[10] Natesan G, Chokkalingam A. An improved grey wolf optimization algorithm based task scheduling in cloud computing environment. Int. Arab J. Inf. Technol. 2020, 17, 73–81.
[11] Gobalakrishnan N, Arun C (2018) A new multi-objective optimal programming model for task scheduling using genetic gray wolf optimization in cloud computing. Comput J 61:1523–1536.
[12] Casas I, Taheri J, Ranjan R, Wang L, Zomaya AY (2018) GA-ETI: an enhanced genetic algorithm for the scheduling of scientific workflows in cloud environments. J Comput Sci 26:318–331
[13] Zhou J, Dong S (2018) Hybrid glowworm swarm optimization for task scheduling in the cloud environment. Eng Optim 50:949 964.
[14] Nanjappan M, Natesan G, Krishnadoss P (2021) An adaptive neuro-fuzzy inference system and black widow optimization approach for optimal resource utilization and task scheduling in a cloud environment. Wireless Pers Commun 121(3):1891–1916
[15] Zhou T, Tang D, Zhu H, Zhang Z (2021) Multi-agent reinforcement learning for online scheduling in smart factories. Robot Comput Integrat Manufact 72
[16] Zade BM, Mansouri N, Javidi MM. A two-stage scheduler based on New Caledonian Crow Learning Algorithm and reinforcement learning strategy for cloud environment. J Network Comput App. 2022 202:103385.
[17] Kaur M (2016) Elitist multi-objective bacterial foraging evolutionary algorithm for multi-criteria based grid scheduling problem. International Conference on Internet of Things and Applications (IOTA) 431–436:2016.
[18] Ibrahim Attiya, Mohamed Abd Elaziz and Shengwu Xiong, “Job Scheduling in Cloud Computing Using a Modified Harris Hawks Optimization and Simulated Annealing Algorithm”, Computational Intelligence and Neuroacience, Hindawi, pp-1-17, 2020.
[19] Jignesh Lakhani and Hitesh A. Bheda, “An Approach to Optimized Resource Scheduling using Task Grouping in Cloud”, International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 3, Issue 9, pp. 594-600, 2013.
[20] Jocksam G. de Matos, Carla K. de M. Marques and Carlos H. P. Liberalino, “Genetic and Static Algorithm for Task Scheduling in Cloud Computing”, Int. J. Cloud Computing, Vol. 8, No. 1, pp-1-19, 2019.
[21] Kalka Dubey, Mohit Kumar and S. C. Sharma, “Modified HEFT Algorithm for Task Scheduling in Cloud Environment”, 6th International Conference on Smart Computing and Communications, ICSCC, Kurukshetra, India, Elsevier, pp-725- 732, 2017.
[22] Kiranveer Kaur and Amritpal Kaur, “Optimal Scheduling and Load Balancing in Cloud using Enhanced Genetic Algorithm”, International Journal of Computer Applications, Volume 125, No. 11, pp-1-6, 2015.
[23] Kvn Krishna Mohan, K Prem Sai Reddy, K Geetha Sri, A Prabhu Deva and M. Sundarababu, “Efficient Big Data Processing in Haddop Map Reduce”, Special Issue on 5th National Conference on Recent Trends in Information Technology, P.V.P. Siddhartha Institute of Technology Kanuru, Vijayawada, India, International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 6, Issue 3, pp. 1-5, 2016.
[24] Kshirsagar, P. R., Yadav, R. K., Patil, N. N., & Makarand L, M. (2022). Intrusion Detection System Attack Detection and Classification Model with Feed-Forward LSTM Gate in Conventional Dataset. Machine Learning Applications in Engineering Education and Management, 2(1), 20–29. Retrieved from http://yashikajournals.com/index.php/mlaeem/article/view/21
[25] Gangula, R. ., Vutukuru, M. M. ., & Kumar M., R. . (2023). Network Intrusion Detection Method Using Stacked BILSTM Elastic Regression Classifier with Aquila Optimizer Algorithm for Internet of Things (IoT). International Journal on Recent and Innovation Trends in Computing and Communication, 11(2s), 118–131. https://doi.org/10.17762/ijritcc.v11i2s.6035