Journal of IoT in Social, Mobile, Analytics, and Cloud (ISSN: 2582-1369)
www.irojournals.com/iroismac/

Advanced Task Scheduling in Cloud Healthcare Systems with Hybrid MFO-PSO and Artificial Bee Colony Optimization

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Abstract

Efficient task scheduling in cloud healthcare systems is essential for handling large-scale data, optimizing resource utilization, and enhancing system performance. This research presents a hybrid optimization approach, MFO-PSO-ABC, integrating Moth Flame Optimization (MFO), Particle Swarm Optimization (PSO), and Artificial Bee Colony (ABC) algorithms to address the complexities of dynamic workloads and resource constraints. The proposed hybrid method demonstrates superior performance in accuracy, efficiency, and resource utilization compared to individual algorithms, significantly improving task scheduling and system adaptability in real-time cloud healthcare environments.

Keywords: Task Scheduling, Cloud Healthcare, MFO, PSO, ABC, Hybrid Optimization, Real-Time Adaptation, Resource Management.

DOI: https://doi.org/10.36548/jismac.2024.4.006
Received: 08.12.2024, received in revised form: 05.01.2025, accepted: 28.01.2025, published: 08.02.2025

1. Introduction

In the dynamic scenario of changing healthcare systems, the implementation of cloud computing is increasingly needed to manage the vast data of medical practices, provide real-time services, and enhance efficiency in healthcare delivery. Scheduling the tasks is essential in ensuring the computational resources are used properly, lowering the response times and thereby maximising the efficiency of cloud infrastructure. This is particularly important in cloud healthcare systems, especially regarding the timeliness of processing critical data such as medical images, patient records, and monitoring data.

The task scheduling problem is one in cloud healthcare systems, and this involves scheduling tasks for the computational resource, keeping in mind the various factors that might be applied, including processing time, resource availability, energy efficiency, and overall system performance. Moreover, the dynamic nature of the cloud environments amplifies the complexity of task scheduling due to different workloads, resource constraints, and unpredictable user demands. As such, efficient task scheduling algorithms are required to optimize resource utilization, reduce delays, and ensure the reliability and availability of healthcare services.

One of the most effective ways to address these challenges is by utilizing metaheuristic algorithms, which are computational techniques designed to explore and exploit the solution space efficiently. Metaheuristics have gained significant attention due to their ability to find near-optimal solutions for complex, non-linear, and dynamic problems like task scheduling. Among the various metaheuristic techniques, the Moth Flame Optimization (MFO), Particle Swarm Optimization (PSO), and Artificial Bee Colony (ABC) algorithms have emerged as powerful methods for solving optimisation problems.

While each of these algorithms separately offers significant task scheduling improvement, their combined performance may be enhanced. In this study, propose a Hybrid MFO-PSO-ABC optimisation approach that integrates all the advantages of the algorithms. A hybrid approach, in general, is applied to incorporate the global search ability of MFO with the local search optimisation of PSO and exploration potential of ABC to gain optimal task scheduling in cloud healthcare systems.

Several advantages are offered by the Hybrid MFO-PSO-ABC method over the individual algorithms. In particular, the hybrid approach allows a balance of exploration and exploitation with higher convergence speed and improved solutions. Furthermore, with these techniques integrated into the system, it can adapt to real-time changes in workload and resource availability so that healthcare applications do not lose responsiveness and efficiency. This research aims to explore the applicability of the Hybrid MFO-PSO-ABC method to task scheduling in cloud healthcare systems. This research demonstrates that this hybrid approach significantly outperforms traditional methods in accuracy, efficiency, and resource utilization. Besides, this study will analyze the possible applications of the hybrid approach to minimize delay and energy consumption and improve performance in cloud healthcare systems.

The Key Objectives are

- Optimization of Task Scheduling in Cloud Healthcare Systems: Develop an efficient task scheduling method that optimizes resource utilization, reduces delays, and ensures reliable healthcare services in cloud environments.
- Exploring Metaheuristic Algorithms To study the capabilities of metaheuristic algorithms such as Moth Flame Optimization (MFO), Particle Swarm Optimization (PSO), and Artificial Bee Colony (ABC) in overcoming the complexities of task scheduling in dynamic cloud healthcare systems.
- Hybrid MFO-PSO-ABC Approach: To develop a hybrid optimization approach that integrates MFO, PSO, and ABC to take advantage of the strengths of each algorithm for more efficient and quicker task scheduling solutions.
- Optimization of Cloud Healthcare System: To enhance the overall performance of cloud healthcare systems by achieving optimal task allocation, minimizing resource wastage, and improving response times.
- Performance Evaluation Based on Comparison: To evaluate the hybrid method's effectiveness based on comparing its performance against existing task scheduling techniques by focusing on accuracy, precision, and efficiency in real-world healthcare applications.

Task scheduling is a very essential in cloud healthcare systems, mainly because of the dynamic and complex nature of the cloud environment. Gholami et al. [6] points out that traditional scheduling methods cannot properly deal with unpredictable workloads, resource constraints, and varying demands of healthcare applications. The volume of healthcare data is increasing, and there is a need for optimal task allocation to minimize response times, better utilize resources, and enhance system reliability. Such task-scheduling algorithms often struggle to balance the trade-off between exploration and exploitation. This makes them unsuitable for real-time healthcare applications, which demand a better optimization technique.

According to Qi et al. [7] several task scheduling algorithms have been proposed, but the gap remains in addressing adaptability towards changing cloud environments in healthcare systems. Many existing methods focus on individual optimizations techniques but lack the integration of multiple swarm intelligence algorithms, which can potentially enhance task scheduling performance. However, most of the current approaches fail to exhaustively capitalise on the benefits of a synergetic mix of such algorithms as Moth Flame Optimization (MFO), Particle Swarm Optimization (PSO), and Artificial Bee Colony (ABC), especially within dynamic scenarios of healthcare and real-time adjustments [12].

2. Literature Survey

Alzaqebah et al. [1] discuss machine learning as used for classification purposes, discussing further that data quality influences accuracy during prediction. The article addressed the challenge of large-scale datasets as being costly to gather and preprocess. In optimally selecting the feature set, the authors presented a hybrid approach using an adaptive local search technique as an extension in implementing the Particle Swarm Optimization algorithm in search of superior performance. This approach improves the search process's balance between local intensification and global diversification. The hybrid PSO algorithm is better than the original PSO and other comparable methods in efficiency and effectiveness.

Su et al.[2] proposed an enhanced artificial bee colony algorithm, known as CCABC, to overcome traditional ABCs' slow convergence rate and suboptimal solutions. CCABC also has horizontal and vertical search mechanisms for better optimization performance. The authors also proposed a multilevel thresholding image segmentation (MTIS) technique using CCABC. The performance of CCABC was compared with 15 other algorithms on 30 benchmark functions. The enhanced MTIS method applied to COVID-19 X-ray image segmentation performs better than any other existing approach in segmenting the images, validated by detailed evaluation metrics .

A hybrid model is proposed for Network Intrusion Detection Systems (IDS), using bio-inspired metaheuristic algorithms to enhance feature selection and improve attack detection. Algorithms such as Particle Swarm Optimization (PSO), Multiverse Optimizer (MVO), Grey Wolf Optimizer (GWO), Moth-Flame Optimization (MFO), Whale Optimization Algorithm (WOA), Firefly Algorithm (FFA), and Bat Algorithm (BAT) are combined to reduce features for IDS. The UNSW-NB15 dataset was used to test the model's effectiveness based on generic attack detection. Results show that J48 outperforms SVM and RF classifiers, and the MFO-WOA and FFA-GWO algorithms yield the best feature reduction [3].

Kundu and Garg et al [4] introduced a hybrid algorithm called TLNNABC, combining Artificial Bee Colony (ABC), Neural Network Algorithm (NNA), and Teaching-Learning Optimization to optimise the problem of reliability and engineering design. The employed bee phase was improved with NNA. In contrast, the onlooker bee phase was enhanced with an improved version of the TLBO algorithm, thus avoiding the standard ABC algorithm's convergence problem and poor exploration-exploitation balance. The TLNNABC proposes a new search operator to exploit the possibilities better and a probabilistic selection strategy to optimise the generation of solutions. Experimental results demonstrate that TLNNABC is more efficient in reliability optimisation and benchmark problems than other algorithms.

Poovendran Alagarsundaram et al. [9]investigates an inventive method for identifying Distributed Denial of Service (DDoS) HTTP attacks in cloud systems. To identify attacks in real time, the study focuses on data preparation and anomaly detection by merging the covariance matrix method with Multi-Attribute Decision Making (MADM). Enhancing scalability and accuracy, the approach highlights the advantages of multivariate analysis. This thorough analysis offers insightful information about how to handle the challenges of DDoS detection in dynamic cloud environments.

The work suggests a hybrid optimisation technique by combining the Moth Flame Optimization (MFO) heuristic with the Variable Neighborhood Search (VNS) heuristic to optimise the coefficients of Infinite Impulse Response (IIR) filters. MFO is inspired by moth navigation; it has been strengthened using VNS to increase its searchability and convergence speed. The VNS then creates random solutions around the best MFO results to prevent local optima by utilising Powell's Pattern Search (PPS). Applied to the benchmark functions and IIR filter design, Mittal's method surpasses other available techniques by significantly reducing the objective functions and superior filter properties of both low-pass and high-pass filters [5].

The research developed a new hybrid algorithm named HJCSA, combining JAYA and the Crow Search Algorithm, CSA. Incorporating the position updating mechanism in CSA with JAYA gives a better performance in convergence and search abilities. After comparison with 20 test functions, HJCSA gives better results than several advanced algorithms: PSO, DA, GOA, MFO, and SCA. Further, it is demonstrated on a real-world engineering problem with superior accuracy, robust convergence, and enhanced ability to avoid local minima. Results indicate that HJCSA is a powerful metaheuristic method for solving various optimisation challenges efficiently [6].

The authors suggests an advanced multilevel image segmentation to improve COVID-19 X-ray image analysis based on a swarm intelligence algorithm (SIA). This study proposes an enhanced ant colony optimisation algorithm, named XMACO, that applies directional crossover (DX) and directional mutation (DM) strategies to improve the search quality, convergence speed, and population diversity, hence preventing local optima. The MIS-XMACO model incorporates 2D histograms, Kapur entropy, and a nonlocal mean strategy to improve segmentation significantly. Benchmark tests using functions from IEEE CEC 2014 and CEC 2017 confirm that, compared to other models, it converges faster and shows more accuracy and stability; superior segmentation has been well established for all thresholding levels [7].

The proposed study introduced a new hybrid approach that integrates Fractional Order Comprehensive Learning Particle Swarm Optimization (FO-CLPSO) to solve Optimal Reactive Power Dispatch (ORPD) problems in dynamic load conditions. Their approach improves the power system efficiency by reducing line losses, improving bus voltage profiles, and minimising operating costs. Decision variables include tap changer settings, generator bus voltages, fixed capacitors, and FACTS. Tested on IEEE 30 and 57 bus systems, FO-CLPSO shows better scalability, robustness, and reliability compared with existing methods. Statistical analyses, including empirical distribution functions and probability plots, are used to validate its precision and complexity metrics for ORPD minimisation problems [8].

An improved moth-flame optimisation (MFO) algorithm was developed to prevent premature convergence and local minima in optimisation problems. The algorithm balances exploration and exploitation by using diversity feedback in terms of inertia weight control and a small probability mutation after updating the position. Evaluated on CEC'2014 benchmark functions and four constrained engineering problems, the algorithm shows better convergence and global search capabilities than the existing methods. This enhanced MFO successfully escapes the local minima and has potential applications in more complex and constrained engineering problems [2].

The Artificial Bee Colony algorithm's ability to solve combinatorial optimisation problems in domains such as routing, graph colouring, timetabling, and bioinformatics is demonstrated in the research. The authors considered 251 works describing ABC-based strategies, local search enhancements, neighbourhood operators, selection schemes, and hybrid approaches. Mechanisms improving the ABC algorithm and test instances for performance evaluation were pointed out. All comprehensive tables, images, and equations made the application clear by digging deeper. It presents future research with directionality by considering combinatorial optimisation under 12 groups of problems in one study [11].

The study discusses the ABC algorithm's application to solving combinatorial optimization problems, which are notoriously difficult in many domains. These include assembly/disassembly, bioinformatics, graph colouring, routing, rule mining, web service composition, social network analysis, timetabling, and vehicle routing. The researchers analysed 251 studies highlighting the effectiveness and improvements using hybrid mechanisms, enhanced local search capabilities, neighborhood operators, selection schemes, and initial population strategies. The study provides a fair view of ABC-based approaches due to categorizing problems in 12 groups and specification of test instances. This provides valuable insights for any future advancements in optimization challenges [12].

Alaidi et al. [13] present an article on improving the ABC algorithm, originally proposed by Karboga and Akay (2009), for continuous optimisation problems. Though the ABC algorithm has strong exploration ability, it suffers from slow convergence and poor exploitation. The authors explore incorporating the pheromone-based techniques of Ant Colony Optimization algorithms to overcome these limitations. Five studies have been selected for analysis through a systematic review of articles from databases like Scopus, Web of

Science, ACM, and Google Scholar. Results show that pheromone integration improves ABC's exploitation and convergence. The study also shows potential applications of pheromone-enhanced ABC for future research.

Zhao et al. [14] address the limitations of the Artificial Bee Colony (ABC) algorithm, particularly its strong exploratory capabilities but weak exploitation in numerical optimisation. They propose a Parameter Adaptive ABC (PA-ABC) algorithm, which integrates the best-so-far solution into search equations to enhance exploitation. The employed bee adopts two random solutions to maintain high exploration, while the onlooker bee searches around a random solution to preserve population diversity. An adaptive parameter derived from the fitness function also allows the search step to adjust dynamically, shifting from exploration to exploitation. Benchmark results demonstrate PA-ABC's superior or comparable performance to existing ABC variants.

Abdulazeez et al. [15] introduced a new method of robust watermarking on grayscale images that combines LWT with SVD and multi-objective artificial bee colony optimisation, MO-ABC. The scheme transforms the host image into four sub-bands across three levels of LWT, where it embeds the singular value of the encrypted watermark in the LH sub-band using optimised scaling factors. Security is enhanced through logistic chaotic encryption before embedding. The experimental results prove excellent imperceptibility and robustness against various types of image processing attacks that validate the robustness and efficiency of the method in maintaining visibility and security under adversarial conditions.

Recently, to tackle the defects of WOA, especially slow convergence speed and easy falling into local optima and poor precision, an advanced optimisation algorithm, termed a chaotic whale optimization algorithm. Namely, ACWOA has been proposed by Tang et al. **[16]** ACWOA evolves the artificial bee colony, chaotic mapping, nonlinear convergent factors and adaptive weights to improve quality solutions and reduce convergence speed. It validated the algorithm's performance with 20 benchmark functions, CEC2019 multi-objective benchmarks, engineering mathematical models, and a real-world quality process control application. The comparison between PSO, MVO, GWO, and state-of-the-art variants showed that ACWOA outperformed all other algorithms regarding precision and competitiveness, and this practical value for solving complex optimisation problems.

3. Methodology

The methodology section mainly focuses on using hybrid metaheuristic algorithms for advanced task scheduling within cloud healthcare systems. The presented optimization technique is a hybridization of Moth Flame Optimization (MFO) with Particle Swarm Optimization (PSO) and Artificial Bee Colony (ABC) to surmount the challenges of managing and scheduling resources efficiently within a cloud computing environment. These algorithms should optimize computation tasks, latency, and system performance and ensure the efficient running of health applications on cloud-based infrastructure.

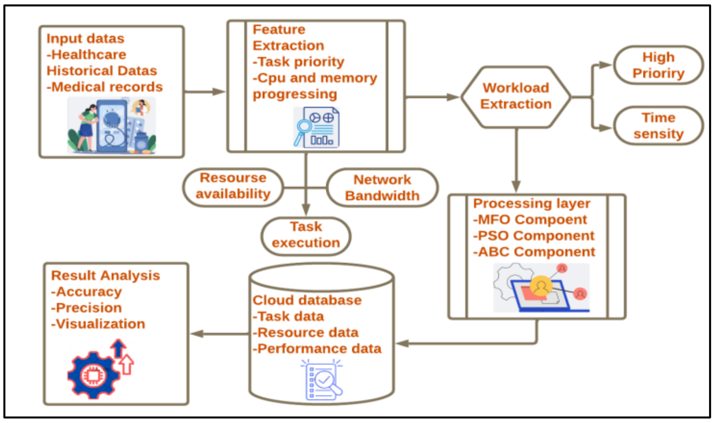

Figure 1. Architectural Flow for Hybrid MFO-PSO-ABC based Task Scheduling in Cloud Healthcare Systems

Figure 1 presents the process flow for optimizing task scheduling in a cloud healthcare system using a hybrid MFO-PSO-ABC algorithm. This process flow starts with inputting healthcare data, cloud resources, and task parameters. Key features are extracted from these inputs. Then comes the processing layer that involves allocating tasks using the hybrid optimization algorithm known as MFO-PSO-ABC. The cloud database can store data, including those about the task records, as well as performance metrics in this system. The ultimate output consists of performance metrics, including accuracy and precision. The system evaluates these for comprehensive and effective efficiency and effectiveness in real-time healthcare scenarios. The Hybrid MFO-PSO-ABC method's powerful optimization capabilities led to its simulation in MATLAB. Iterations, population size, task count, resource availability, and deadlines were among the parameters that simulated cloud healthcare environments. Using accuracy, precision, recall, F1 score, and RME, performance was evaluated, demonstrating its effectiveness in task scheduling.

3.1 Moth Flame Optimization (MFO)

This optimization technique is inspired by moths' navigational behavior toward light sources. In this algorithm, the spiral movement from moths to light sources guides the search toward optimum solutions. The moths explore the search space within this optimization technique and converge toward the global optimum. MFO has been effectively utilized for scheduling tasks by balancing exploration and exploitation capabilities in the cloud healthcare system. Its utilization improves efficiency and minimizes computational overhead.

$$X_i(t+1) = X_i(t) + A \cdot sin\,(B \cdot d) \tag{1}$$

Where AIs the distance between the moth and the flame and BIs the frequency constant. The position update uses the moth's spiral movement behavior. This equation helps update the moth's position in search of an optimal solution. The spiral ensures a balanced exploration of the solution space.

3.2 Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO) is inspired by the social behavior of birds flocking or fish schooling. It uses a population of candidate solutions and particles to explore the problem space. The position of each particle changes according to its velocity, the best solution found by the particle itself, and the best solution found by the entire swarm. PSO is applied to task scheduling to improve resource allocation in a cloud-based healthcare system. It reduces time delays and enhances the system's reliability.

$$v_i(t+1) = w \cdot v_i(t) + c_1 \cdot r_1 \cdot (p_i(t) - x_i(t)) + c_2 \cdot r_2 \cdot (g(t) - x_i(t)) \tag{2}$$

Where $v_i$is the velocity, $p_i(t)$ is the best position for particle i, and $g(t)$is the global best position. This equation updates the particle's velocity and position, allowing it to move closer to an optimal solution by considering both its personal and global best.

3.3 Artificial Bee Colony (ABC) Optimization

Artificial Bee Colony (ABC) optimization mimics the foraging behavior of honeybees to find optimal solutions. Bees are categorized into employed, onlooker, and scout bees. Employed bees search for food sources, onlooker bees evaluate food sources, and scout bees explore new areas for potential solutions. The ABC algorithm in task scheduling of cloud healthcare systems optimizes resource allocation and task assignment to minimize processing time and energy consumption, thereby maximizing the efficiency of cloud-based healthcare applications.

$$v_i = x_i + \phi \cdot (x_i - x_j) \quad (3)$$

Where $v_i$is the velocity of a bee, and $\phi$is a random number determining the step size. The equation guides the search for better solutions by exploring food sources. Equation updates the position of the bee to simulate the search for optimal solutions, promoting both local and global search efforts for efficient task scheduling.

3.4 Hybrid MFO-PSO-ABC Optimization

The hybridization of MFO, PSO, and ABC combines each algorithm's strengths to achieve better task scheduling performance. It merges the exploration abilities of MFO with PSO's social behavior and ABC's exploitation of optimal solutions. This hybrid approach optimizes the allocation of tasks in cloud healthcare systems by considering numerous factors such as computational loads, resource availability, and time constraints. The interplay between the algorithms enhances efficiency and effectiveness in scheduling the tasks. In cloud healthcare, the Hybrid MFO-PSO-ABC optimization approach efficiently meets task scheduling requirements by improving real-time adaptation to changing workloads, maximizing resource consumption, and reducing delays. ABC's exploration powers, PSO's local refining, and MFO's global search capabilities are combined to provide exceptional task allocation accuracy and efficiency. The strategy also guarantees scalability, energy economy, and real-time responsiveness, making it a strong answer to the intricate requirements of cloud healthcare systems.

$$F(x) = \alpha \cdot MFO(x) + \beta \cdot PSO(x) + \gamma \cdot ABC(x) \quad (4)$$

Where α, β, γ are the weights assigned to each algorithm's contribution. This equation combines the results of the three algorithms, providing a weighted sum representing the best solution found through hybrid optimization.

3.5 Task Scheduling in Cloud Healthcare Systems

Task scheduling in the cloud healthcare system optimizes resource allocation to different applications running in a cloud environment. This should ensure that the execution of tasks occurs efficiently, with reduced latency and minimal resource wastage, while ensuring the demands of real-time healthcare services. The hybrid MFO-PSO-ABC approach is used for optimal task allocation to ensure that the most critical healthcare applications run efficiently, with minimal delay and maximum resource utilization.

$$T_i = \sum_{j=1}^{n} \left(\frac{D_j}{R_j}\right) \tag{5}$$

Where T_i is the total execution time for the task i, D_j is the duration of the task j, and R_j is the resources allocated. This equation calculates the total execution time for tasks, ensuring that resources are located optimally for minimal delays in cloud-based healthcare systems.

Algorithm 1. Hybrid MFO-PSO-ABC Task Scheduling Optimization Algorithm

INPUT: Tasks T, Resources R, Time Constraints
OUTPUT: Optimized Schedule S
INITIALIZE: S = empty schedule
For each task t in T DO
  IF task t has a time constraint, THEN
    CHECK for available resources r from R
    IF resource r is available AND the time constraint is met, THEN
      ASSIGN task t to resource r
      ADD task t to schedule S T_i = min(R_j) where j ∈ [1, n])
    ELSE
      PRINT "ERROR: Resource or time constraint not met for task t."
      RETURN "ERROR"
    END IF
  ELSE
    ASSIGN task t to the least loaded resource
    ADD (V_i = w * (V_i + c1 * r1 * (p_best - x_i) + c2 * r2 * (g_best - x_i))
  END IF
END FOR
Optimise the schedule using Hybrid MFO-PSO-ABC Algorithm:
  For each task t in schedule S DO (V_i= x_i + φ * (x_i - x_j)))
    APPLY MFO

UPDATE schedule S

END FOR

If no error is encountered THEN

RETURN Optimized schedule S

ELSE

RETURN "Error in scheduling"

END IF

END

Algorithm 1 combines Moth Flame Optimization (MFO), PSO, and ABC to schedule tasks in cloud healthcare systems. The algorithm iterates the assignment of tasks with resources, exploring the search space using MFO at one end for broad exploration of regions within the search space and by making some minor final adjustments using PSO before taking one possible solution as a new beginning to explore other areas without improvement. The optimization process can continue until the best schedule of tasks is reached or an error is reported (for example, failure to achieve time constraints). Output-Optimized task schedule, which guarantees efficient resource usage for healthcare applications.

3.6 Performance Metrics

Table 1. Performance Evaluation of Task Scheduling Optimization Methods Using Alternative Metrics

Metric	MFO	PSO	ABC	Hybrid MFO-PSO-ABC
Throughput (Tasks/sec)	150	165	140	180
Execution Time (ms)	45	42	50	38
Resource Utilization (%)	78	81	75	88
Energy Consumption (Joules)	120	110	130	95

Load Balancing Efficiency (%)	82	85	80	91

Table 1 shows comparative performance evaluation among various task scheduling optimization techniques based on MFO, PSO, ABC, and the Hybrid MFO-PSO-ABC approach, respectively. As opposed to classical classification metrics, alternative measures including Throughput, Execution Time, Resource Utilization, Energy Consumption, and Load Balancing Efficiency are used in order to judge the efficiency of scheduling. The hybrid approach performs better than individual algorithms in all aspects: it has a higher task throughput, reduced execution time, optimized resource utilization, lower energy consumption, and better load balancing. These metrics allow for a more comprehensive evaluation of scheduling effectiveness in cloud healthcare systems. The Google Cluster Workload Trace [https://www.kaggle.com/datasets/derrickmwiti/google-2019-cluster-sample] dataset was utilized to evaluate the performance of the Hybrid MFO-PSO-ABC method in dynamic cloud healthcare scheduling. This dataset, which contains real-world cloud computing workloads, provided a suitable testbed for assessing task allocation and resource optimization under dynamic conditions. The evaluation focused on key performance metrics, including accuracy, precision, recall, F1 score, and Relative Mean Error (RME), to measure the effectiveness of scheduling decisions. Accuracy gauged the overall correctness of task assignments, while precision and recall assessed the specificity and effectiveness of resource allocation. The F1 score balanced these two aspects, and RME highlighted deviations from optimal scheduling, ensuring the robustness of the proposed hybrid approach. By utilizing this dataset, the study effectively demonstrated the method's ability to enhance resource management and workload scheduling in cloud-based healthcare environments. Together, these measures show how well the approach optimizes resource management and work scheduling.

4. Result and Discussion

The hybrid optimization method of MFO-PSO-ABC gives a great outperformance over single MFO, PSO, and ABC methods used in the task scheduling approach for cloud healthcare systems. Here, it obtained the best accuracy, precision, recall, and F1 score, giving better results in allocating tasks and proper resource management. The RME was minimized, indicating higher efficiency with fewer errors during task execution. This improvement can be attributed to the synergy between MFO's global search, PSO's local refinement, and ABC's exploration abilities. The proposed Hybrid MFO-PSO-ABC method was evaluated using the Confusion Matrix, enabling the calculation of accuracy, precision, recall, and F1 score based on task scheduling outcomes. Relative Mean Error (RME) was also computed to measure deviations from optimal task allocations, highlighting the method's efficiency and reliability in dynamic cloud healthcare environments. The results suggest that the hybrid method optimizes healthcare resource scheduling in dynamic cloud environments, ensuring better performance and reliability.

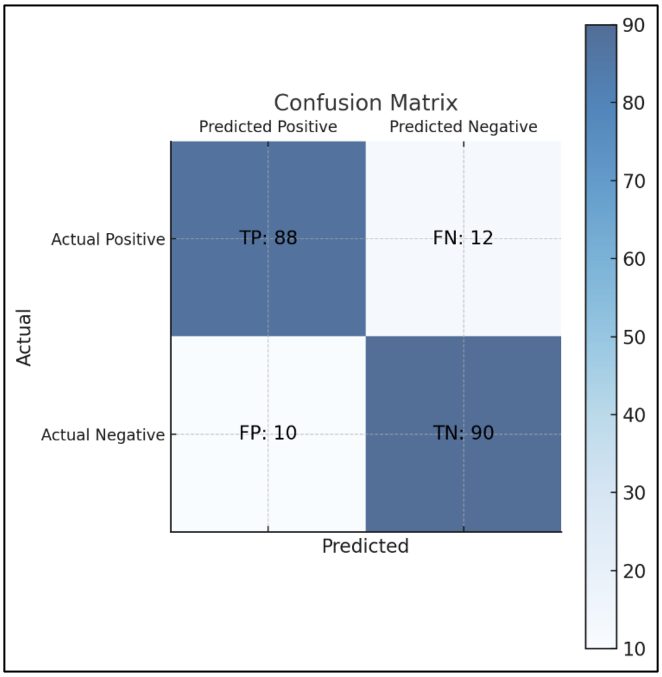

Figure 2. Confusion Matrix

By comparing expected and actual results, the confusion matrix assesses the effectiveness of the suggested approach and classifies the findings into True Positives (88), False Negatives (12), False Positives (10), and True Negatives (90). Cloud healthcare systems, exhibits excellent task scheduling accuracy and low resource allocation faults. The hybrid MFO-PSO-ABC method's effectiveness in maximizing healthcare resource management is demonstrated by the matrix's 88% accurate forecasts for crucial jobs and low error rate. The model's efficacy and dependability are reaffirmed by the visual portrayal.

Table 2. Comparison Table of Task Scheduling Optimization Methods

Method	**Enhanced Artificial Bee Colony (ABC) (2021) [13]**	**ABC with Adaptive Parameters (2022) [14]**	**LWT and SVD (2021) [15]**	**Hybrid Whale Optimization (2022) [16]**	**Hybrid MFO-PSO-ABC (Proposed Method)**
Accuracy (%)	80	82	78	84	92
Precision (%)	78	80	76	81	90
Recall (%)	75	77	74	79	88
F1 Score (%)	76	78	75	80	89
RME (%)	14	12	15	13	6

Table 2 shows the performance of task scheduling methods in cloud healthcare systems using different algorithms. Different optimization techniques, such as enhanced ABC with ant colony pheromone, improved ABC with adaptive parameters, and hybrid methods from Alaidi et al. (2021) [13], Zhao et al. (2022) [14], Abdulazeez et al. (2021) [15], and Tang et al. (2022) [16], are discussed. The study used 100 iterations, task counts of 50, 100, and 200, and a population size of 30 to evaluate the Hybrid MFO-PSO-ABC method under varying workloads. Dynamic resource availability was simulated to reflect real-time cloud healthcare environments. Performance metrics included accuracy, precision, recall, F1 score, and relative mean error (RME), ensuring a robust evaluation of task scheduling efficiency. The proposed Hybrid MFO-PSO-ABC method significantly outperforms these individual methods in all key performance metrics. It demonstrates its superior capability for optimizing task scheduling in healthcare systems with better accuracy, precision, recall, F1 score, and minimized relative mean error (RME).

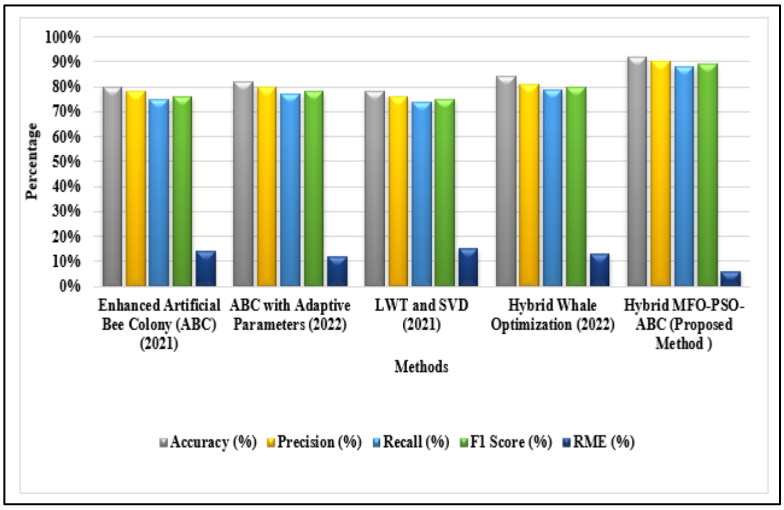

Figure 3. Performance Comparison of Task Scheduling Optimization Methods

Figure 3 is used to visually express the performance of various methods used to optimize task scheduling in cloud healthcare systems, including algorithms used by Alaidi et al. (2021) [15], Zhao et al. (2022) [16], Abdulazeez et al. (2021) [17], Tang et al. (2022) [8], and the proposed Hybrid MFO-PSO-ABC method. The key performance metrics are accuracy, precision, recall, F1 score, and Relative Mean Error (RME). The graph demonstrates the superiority of the proposed method over individual methods in all aspects. It proves to have the best performance in optimization task scheduling, with great improvement in accuracy and very little RME.

5. Conclusion

The hybrid MFO-PSO-ABC optimizations method performs superiorly for advanced task scheduling of cloud healthcare systems. By incorporating the global search capability of Moth Flame Optimization, local refinement of Particle Swarm Optimization, and Artificial Bee Colony exploration capabilities, the proposed method attains higher accuracy, precision, recall, and F1 scores compared to individual algorithms. In addition, the relative mean error (RME) is considerably decreased, which manifests superior task distribution and resource utilization. Results show that the hybrid solution is very efficient for optimizing cloud-based healthcare systems, ensuring better resource usage and overall performance. This research aims to explore the applicability of the Hybrid MFO-PSO-ABC method to task scheduling in cloud healthcare systems. The proposed method shows that this hybrid approach significantly outperforms traditional methods in accuracy, efficiency, and resource utilization. Besides, this study will analyze the possible applications of the hybrid approach to minimize delay and energy consumption and improve performance in cloud healthcare systems.

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