Section: Research Paper

The methods used for solving Task Scheduling Problem In Cloud Computing Environment

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Abstract

Cloud computing, which has grown in popularity in recent years, allows users to use computational resources remotely over the Internet. One of the trickiest issues about cloud computing is figuring out how efficiently, reliably, and securely map jobs which known as task scheduling. The effective performance of task scheduling is one of the most significant research issues in cloud computing. Numerous algorithms traditional, heuristic and meta-heuristic have been addressed to solve task scheduling in cloud computing. In this paper, we presented various meta-heuristic methods that proved to be the best technique for the task scheduling problem and discussed their limitation.

Index terms: task scheduling, heuristic algorithms, meta-heuristic, task scheduling in cloud computing.

1. Introduction

The Internet's broad use in recent years has led to enormous technological breakthroughs in data processing and storage. The upshot of this technological change was the idea of cloud computing. It transfers data and computing from laptops and desktop PCs to enormous data centers. It is a state-of-the-art technological platform that enables people all over the world to access data on the Internet at any time and use computing. Figuring out how to efficiently, dependable, and securely map jobs, commonly referred to as tasks or applications, to resources is among the difficult aspects of cloud computing. This mapping is known as task scheduling, and it is an NP-hard problem. However, because of its complexity, dynamic nature, high degree of resource and employment uncertainty, problem magnitude, and other considerations including pre-existing local schedulers and norms, it is more challenging (**Younis & Yang**). Users can access computational resources remotely through the Internet due to cloud computing, which has recently grown in popularity.

Cloud computing must be able to cope with a large number of concurrent users. All user requests for high performance and effective service quality must be able to be fulfilled by it (QoS). As a result, in order to fulfil these requests in a timely manner, an efficient job scheduling process must be put in place. Task scheduling is one of the most crucial elements in a cloud computing system because cloud performance is heavily reliant on it. Meta-heuristic algorithms are the best method for resolving complex problems. In contrast to other approaches that have been demonstrated to be extremely efficient and can locate nearly optimal solutions in polynomial time as opposed to exponential time. **(Ivanova et al.,).**

The task scheduling problems in cloud computing are covered in this article. Thus, the remainder of the paper is structured: The overview of task scheduling in cloud computing is covered in Section (2). Section (3) discusses task scheduling algorithms with its types and Section (4) make a brief discussion. Section (5) provides the concluding.

2. Overview of Task scheduling in cloud Computing

Characterized as the capacity to effectively allocate and assign numerous different jobs to numerous VMs and to timely execute all tasks. Scheduling's primary goal is to assign tasks to the appropriate resources in order to fulfil all or some optimisation criteria. Users submit tasks to the cloud scheduler as part of the process, and the cloud scheduler uses a cloud information service to look into the status of the resources. Then, map the tasks to different resources in accordance with their requirements. The most effective approach feasible is used by the efficient scheduler to assign the tasks the necessary resources (such as VMs). The job of the broker is vital as in Figure (1). The list of virtual machines (VMs) and their quality of service (QoS) is available to

brokers. A VM with a high QoS and high performance. The broker receives the user's requests and forwards them to the VM that best satisfies the user's needs and adheres to the service level agreement (SLA). The services quality for the request or task should not degrade when it is assigned to a specific VM. A good Quality of Service (QoS) task is occasionally assigned to a Low QoS VM, resulting in poor resource utilization and a violation of the (SLA). As a result, the broker should use an efficient work scheduling mechanism. **(Al-Arasi & Saif)**

3. Task scheduling algorithms

There are scheduling strategies, for various distributed computer systems. The three basic categories of scheduling techniques are conventional, heuristic and meta-heuristic techniques which are clarified in next sections:

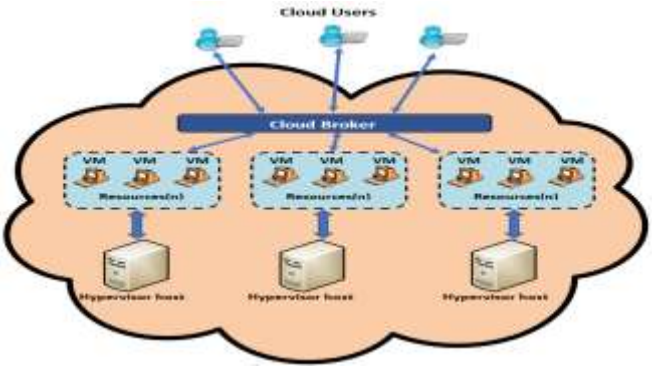

Figure 1. Procedure of task scheduler

3.1 Conventional algorithms

For scheduling different tasks, traditional techniques like Shortest Job First, First Come First Serve, and Round Robin are essential.(**Elmougy et al., Sangwan et al**., **Li et al.**,)
These methods produce accurate solutions and are straightforward, quick, and deterministic.
Improved the execution of RR is used by **H.S. Behera et al**. They reschedule the procedure before it is carried out. It selects the procedure with the shortest burst time, followed by the one with the longest burst time, the second-shortest burst time, and so on. **Sangwan et al**., a revised version of RR is suggested. The best/worst case of the original algorithm is identical to the worst case of the suggested approach, it has been demonstrated using graphs and computations. However, just the average turnaround and waiting times are compared. The number of switch cases used to carry out the method has not been highlighted.
However, in many circumstances they are ineffective for comprehending the optimality problem. Thus, using standard methods in the cloud is not practical. It has been established that task scheduling is a characteristic NP-hard optimization problem that cannot be effectively solved by conventional techniques. Due to their success in resolving issues of great complexity and magnitude, the use of heuristic and meta-heuristic algorithms for task scheduling optimisation has received more attention in recent works.

3.2 Heuristic algorithms

A heuristic **(Desale et al., Abdulredha et al.,)** is a method developed to find an approximation when traditional approaches are unable to find a precise solution or to solve a problem more rapidly when traditional methods are too slow. Heuristics should be considered as approximations rather than precise algorithms because they offer no assurance that the best solution will be discovered.These algorithms typically find a quick and simple solution that is near to the optimal one. Several heuristic techniques were developed in the early stages of work scheduling to deal with the challenge. The majority of heuristic approaches, however, were not successful in raising the quality of solutions for complex situations.

Karuppan et al. used Priority-Based Max-Min to enhanced execution time and resource utilization. However the limitation is that not taking into account the emergence of dynamic tasks and the high potential for resource over/under utilization. **Zhou et al,** Fuzzy dominance-based HEFT has been proposed to increase makepan, CPU runtime, and cost. However, unregulated communication and storage have time and money costs.

The performance of these algorithms rapidly declines as the workflow size increases due to their inability to adapt to various deadline constraints, even though they are efficient under some specific conditions. Consequently, a variety of meta-heuristic strategies are suggested.

3.3 Meta-heuristic algorithms

Allocating tasks to resources in a cloud computing context is an NP-Hard problem. As a result, task scheduling is clarified by employing meta-heuristics and heuristics to arrive at near-optimal or optimal results. Meta-heuristic techniques include heuristic techniques, which are subsets of heuristic techniques. The social behavior of insects is frequently used to inspire meta-heuristic techniques. (**Sharma et al.,**)

One of the main problems with the cloud system is the efficient task scheduling. To tackle the scheduling problem, a variety of optimization strategies, including heuristic techniques, are employed. Heuristic strategies have had a very limited amount of success in many applications as the problem's complexity rises. This limitation results from the time used to find the ideal solution. Heuristic methods lack the required efficiency as a result. Meta-heuristic algorithms, on the other hand, are predicted to get around these limitations and deliver the optimum solution in a shorter amount of time. Compared to conventional and heuristic algorithms, meta-heuristic scheduling algorithms produce better scheduling results. Duo to its effectiveness at handling significant and complicated problems, meta-heuristic algorithms have gained a lot of popularity recently. Finding a balance for solution diversity and intensity is the primary goal of meta-heuristic search. These two principals have the potential to be used to any effective search or optimization method. Diversification is the process of using an effective search space exploration method to reduce trapping in a local minima. Contrarily, intensification concentrates on maximizing the effectiveness of the current solution (**Houssein et al.,**). It can work as a single algorithm or hybridizes with other algorithms such as a heuristic algorithm or other meta-heuristic algorithm as described below

3.3.1. Single meta-heuristic algorithms

Shukri et al., adds a step to the original algorithm and suggests an enhanced Multi-Verse Optimizer as a scheduler. The outcomes of the simulation demonstrate enhanced makespan and resource utilisation.

To improve both makespan and energy consumption, improved rock hyrax algorithm by (**Singhal & Sharma**)

A modified version of DSOS is used on CloudSim by Sa et al., to programme jobs for the cloud. The outcomes showed that the suggested algorithms were capable of shortening the task's duration and response time.

The cost of tasks is the focus of the Spacing Multi-Objective Antlion **Belgacem et al**, provide a dynamic resource allocation strategy that can better and faster response to client demand for resources. The Spacing Multi-Objective Antlion algorithm, a multi-objective search algorithm that lowers the cost and time required to use virtual machines, is also introduced. Investigated were its implications on fault tolerance and energy usage.

In order to achieve its goals of minimising the makespan and maximising resource utilization, **Pradhan and Bisoy** devised a load balancing solution based on modified PSO, which distributes workloads over the available cloud resources. Additionally, in order to do this, they need to be properly informed about the resources and duties within the datacenter. They used the CloudSim simulator to display the results. Which clearly shows that the suggested method performs better than the other available algorithms in terms of reducing the makespan and enhancing resource usage. This technique's drawback is that QoS parameters were not improved.

Table I. Some of existing Single meta-heuristic algorithms

Auther	Techniques
Shukri et al. 2021	Improved Multi-Verse Optimizer as a scheduler by add step to the original algorithm
(Singhal & Sharma, 2021)	Global Rock Hyrax is a concept for achieving local and global optimal solutions.
(Sa et al., 2021)	The method mimics multiple symbiotic interactions to enhance the quality of a particular objective function (mutualism,

	commensalism, and parasitism).
Pradhan & Bisoy 2020	Using modified PSO task scheduling as a load balancing strategy (LBMPSO) by making certain that the datacenter's jobs and resources are properly informed.
Belgacem et al. 2020	Introduce Spacing Multi-Objective Antlion algorithm (S-MOAL)

3.3.2. Hybrid two meta-heuristic algorithms

Many studies have looked into task scheduling based on differential evolution. To address the issue of work scheduling in cloud environments, **Abualigah & Diabat** develop a unique hybrid antlion optimization algorithm with elite-based differential evolution. With this approach, they aimed to reduce makespan and increase resource usage. Elite-based differential evolution has been used to improve the Antlion algorithm by acting as a local search approach to create exploitation and prevent being stuck in local optima. They use CloudSim toolkit. The outcomes demonstrate that the MALO algorithm was quicker than the alternative techniques for higher search sizes, also the results analyzed using T-tests demonstrate that this algorithm got an important advancement in the results. The limitation of this techniques that they did not consider peak demand, memory use, overload, complexity.

Fu et al., They did study on the operation of the cloud scheduling system and the suggested phagocytosis-based strategy. The genetic algorithm divides each generation of the particle swarm, and in order to broaden the search space for the solution, the crossover mutation and phagocytosis processes are utilised to move the particle placements in the subpopulation. In order to ensure particle diversity in the population and reduce the likelihood that the algorithm would start to gravitate towards the local optimal solution, the subpopulations are then mixed. Finally, the feedback mechanism is used to inform the subsequent particle population about the particle's flight experience, including that of its companion.

Velliangiri et al., Hybrid Electro Search utilising a Genetic Algorithm has been demonstrated to optimise work scheduling behaviour by accounting for elements such as makespan, load balancing, resource usage, and multi-cloud cost. The recommended method combines a genetic algorithm and an electrical search algorithm. The genetic algorithm generates the best local optimum solutions, whereas the Electro search method generates the best global optimal solutions. The suggested algorithm falls short of existing scheduling methods, such as the Hybrid Particle Swarm Optimization with Genetic Algorithm, Genetic, and ACO, which guarantee that the particle population can always take the optimum path.

Alboaneen et al., a new metaheuristic method JTSVMP is suggested for cloud data centres to optimise collaborative VM placement and job scheduling. Although collaborative VM placement and job scheduling are two separate components of the JTSVMP problem, they are handled as one problem that needs to be resolved by metaheuristic optimization techniques. The suggested approach seeks to execute jobs inside the virtual machine at the lowest execution cost achievable. The outcomes of two distinct scenarios are compared and contrasted. The simulation findings demonstrate that by maximising resource utilisation and decreasing execution cost, makespan, and degree of imbalance, coupled task scheduling and VM placement optimisation leads to better overall results.

Table II. Some of existing hybrid two meta-heuristic algorithms

Author	Techniques
Abualigah & Diabat 2021	The Antlion algorithm has been enhanced by including elite based differential algorithm to consider as a local search approach for developing exploitation and avoiding local optima
(Fu et al., 2021)	The position of the particles is modified using crossover and mutation of genetic algorithm and phagocytosis mechanism
(Velliangiri et al., 2021)	The genetic for best local solutions, while Electro algorithm for best global solutions.
(Alboaneen et	Within a deadline limitation, assign

al., 2021)	tasks to the virtual machine with the minimum execution cost, and then, within a capacity restriction, place the chosen VM on the physical host (PH) that is being utilized the most frequently.
(Annie & Radhamani, 2021)	HHO allocates tasks by identifying the overload and under load situation of VMs and improving response time using a PIO-based technique.

3.3.3. Hybrid Meta-heuristic and Heuristic algorithms

Pirozmand et al. which solves job scheduling by boosting time and energy usage while incorporating energy-conscious scheduling into a hybrid GA algorithm. They introduce the Genetic Algorithm, a two-step hybrid method for scheduling tasks that take energy and time into account, as well as the Energy-Conscious Scheduling Heuristic, which is dependent on the Genetic Algorithm. Tasks are identified in the first step, and tasks are assigned to the processor in the second. Prioritizing jobs was done using this model, which considers energy consumption, produce primary chromosomes, and assign tasks to the processor.
Alsaidy et al., to enhance the initialization of particle swarm optimization, they employed heuristic methods (PSO). They begin the PSO using minimal completion time (MCT) algorithms and employ strategies to send the largest assignment to the processor with the highest speed. Some objective functions, like minimizing the makespan, perform better with the suggested LJFP-PSO and MCT-PSO algorithms. Furthermore, the algorithm's performance is compared to that of existing job scheduling algorithms. When compared to PSO and other algorithms, simulation results utilizing the cloudsim tool proved the usefulness of this technique. The algorithm's shortcoming is that the other parameters aren't taken into account.
Heuristic Task Scheduling with HABC algorithm presented in **(Kruekaew & Kimpan)** to reduce makespan and balance the loads. Task scheduling enhanced the makespan and cost depend on hybrid meta-heuristic with heuristic algorithms is proposed by many researches. **Dubey & Sharma**, introduce Chemical Reaction Partial Swarm Optimization algorithm to enhance cost, energy, and makespan. The simulation results showed that the suggested methods performed admirably for the objective functions under consideration.
The heterogeneous earliest end time (HEFT) and the ant colony method were introduced by **Belgacem and Beghdad-Bey** to enhance the same goal functions, makespan and cost.

Table III. Some of existing hybrid Meta-heuristic and Heuristic algorithms

Auther	Techniques
(Pirozmand et al., 2021)	1-Prioritizing tasks by ECS 2- GA used to put these task in sequence
Alsaidy et al. 2020	The PSO using heuristic techniques metaheuristic algorithm's random initialization has been replaced by (MCT and LJFP).
(Kruekaew & Kimpan, 2020)	HABC with Largest Job First heuristic algorithm.
(Dubey & Sharma, 2021)	Traditional CRO and standard PSO techniques,
(Belgacem & Beghdad-Bey, 2021)	While HEFT is used to address the dependency of process activities, ACO is utilized to optimize resource allocation.

4. Discussion

In this section, we analyze and explain the job scheduling strategies utilised in cloud computing. The debate is based on the characteristics of the three kinds of approaches: conventional, heuristic, and meta-heuristic algorithms. As it can be observed from the numerous modern scheduling methods that were chosen for this study, the meta-heuristic is seen to be the primary scheduling algorithm.

In order to solve specific problems, search and optimization algorithms are often created employing various heuristics. Heuristic algorithms, in contrast, are created for particular issues and lack the strong mathematical basis. Meta-heuristics, the generalised approaches, on the other hand, explain algorithmic frameworks to produce a variety of ways for quickly finding the approximations needed for optimization problems in a vast search space. The current work has focused on scheduling issues using a single meta-heuristic, a hybrid meta-heuristic with heuristic, or two meta-heuristics. Instead of utilizing a single heuristic or traditional algorithms, to achieve the improvement in the outcome.

5. Conclusion

In a cloud context, appropriately assigning tasks to virtual machines might be difficult. The cloud scheduling process has been optimised using a variety of methodologies, however their capacity to handle complex optimisation problems is constrained. Heuristic algorithms, for instance, deliver a precise solution for a specific problem domain in a finite amount of time. Meta-heuristics are distinguished from traditional and heuristic algorithms by certain accuracy and performance characteristics. Heuristic techniques frequently produce solutions that are stuck in the issue of local minima, making them unable to guarantee the best outcome. In contrast, meta-heuristic techniques have proven to be the most successful in avoiding this problem.

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