A Multi-objective Optimal Task Scheduling in Cloud Environment Using Cuckoo Particle Swarm Optimization

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Abstract

In cloud computing, varied demands are placed on the constantly changing resources. The task scheduling place very vital role in cloud computing environments, this scheduling process needs to schedule the tasks to virtual machine while reducing the makespan and cost. The task scheduling problem comes under NP hard category. Efcient scheduling method makes cloud computing services better and faster. In general, optimization algorithms are used to solve the scheduling issues in cloud. So, in this paper we combined two optimization algorithms namely called as Cuckoo Search (CS) and Particle Swarm Optimization (PSO).The new proposed hybrid algorithm is called as, CS and particle swarm optimization (CPSO). Our main purpose of the proposed paper is to reduce the makespan, cost and deadline violation rate. The performance of the proposed CPSO algorithm is evaluated using cloudsim toolkit. From the simulation results our proposed works minimize the makespan, cost, deadline violation rate, when compared to PBACO, ACO, MIN–MIN, and FCFS.

Keywords Cloud computing · Task scheduling · CPSO · Performance and multi-objective

1 Introduction

Cloud computing [1] has been developed in the feld of processing and storing by providing endless way of accessing Information Technology in wide range of domains such as mobile system, network system, environmental computing, medicines, business. Thus lead- ing to the decision of cloud computing at recent times because of its efciency in comput- ing provides IT services. It also includes the infrastructure based on pay-per-use model to eliminate the need of investing for the purpose of managing the IT infrastructure.

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The services provided by the Cloud are categorized as follows: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). The users can access virtual resources by making use of these services. This, therefore, makes the resources fexible. The users have to pay for the services and thus the name "pay-per-use" model became another term for the Cloud. While using cloud services, optimal scheduling becomes a necessity as the users are directly dependent on it for physical resource usage.
In cloud computing, the widely spread problem is task scheduling that remains of the NP- hard problem. In IaaS cloud, a collection of servers are presented to provide the users with required resources. The IaaS cloud not only provides hardware to the users but also software which ensures properties of elasticity and efcient management of resources of the cloud. The subsystem of the resource management in IaaS is used to execute the sched- uled tasks, used to map the tasks that are to be carried in a more efcient manner of VM

characterizing dynamic and heterogeneous property. Good solution is achieved via heu- ristic methods to fnd the optimal solution [2, 3] of the NP-problem. The main aim is to schedule tasks to reduce the cost as well as the execution time. The VM has the capacity of heterogeneous processing that leads to load balancing among Virtual Machines. It is used to provide co-ordination, schedule the tasks and achieve lower make span. Thus, the execu- tion time of VM and balancing load is performed by task scheduling algorithms.
In this paper, we proposed multi-objective-based task scheduling using a combination of cuckoo and particle swarm optimization algorithm. The multi-objective function used in this paper is makespan, cost and deadline violation rate. Based on the multi-objective function we obtain the near optimal scheduled task. The major contribution are made in the research for task scheduling process as follow,
• An approach namely CPSO is done for task scheduling, which has the advantages of quickly converging and easily realizing so that this scheduling approach is able to get a near optimal solution. • Multi objective based task scheduling problems in cloud computing are the focus by considering minimization of makespan, cost and deadline violation rate in the hetero- geneous cloud environment.
• The simulation is done by using cloudsim3.0 toolkit. The rest of the paper is organized as follows; a detailed review of the related work based on task scheduling in cloud environments is described in Sect. 2. In Sect. 3 the problem defnition and system model is presented in detail. The resource cost and task scheduling model is given in Sect. 4. In Sect. 5, The proposed technique for task scheduling using cuckoo particle swarm optimization is described. The experimental results and the per- formance evaluation discussion are provided in Sect. 6. The conclusion is summed up in Sect. 7.

2 Related work

In [4], the scheduling and maintenance of the cloud resources present in the cloud envi- ronment are done by the deadline-based job scheduling and Particle Swarm Optimisa- tion (PSO)-based resource allocation mechanism. Using these mechanisms, the Cloud Resource Broker is implemented. The number of jobs can be increased and the time, cost can be decreased by this technique. In [5], the multi-objective scheduling technique which

was proposed is found to be reducing the cost, makespan, and all the other objectives to a considerable rate. The Ant Colony Optimization (ACO) method is used for evaluation and for reviewing the performance and cost of budget. In [6], the multi objective function for scheduling is achieved by making use of a hybrid cuckoo search and gravitational search algorithm (CGSA). Their work focused on allocating entire task to an equivalent virtual machine while maximizing the proft the entire task was executed with low cost, less resource use, and less energy consumption. In [7], the work focused on six rules based heuristic algorithms namely, First Come First Serve (FCFS), Minimum Completion Time (MCT), Minimum Execution Time (MET), Max–min, Min–min and Sufrage to execute and schedule autonomous jobs in homogeneous and heterogeneous environment. Their aim was to compare processing in terms of cost, degree of imbalance, makespan and throughput.

In [8], the authors proposed scheduling algorithm named Global League Championship Algorithm (GBLCA) for global job scheduling of scientifc applications in a cloud environment. This algorithm showed a remarkable process development rate on the make span that ranges between 14.44 and 46.41securely schedule the applications. In [1], The Simulated Annealing (SA)-based Symbi-

otic Organisms Search (SASOS) technique was presented so that the convergence rate and solution quality is increased. The objective is to optimize the scheduling of the jobs in the cloud. This technique is similar to PSO algorithm when it comes to efciency of response time. Moreover, the utilization level of the VMs was taken into consideration for a ftness function in order to bring down the degree of imbalance. The work in [9] addressed the issue of job scheduling and resource provisioning for a set of jobs that executed on IaaS clouds. The proposed algorithm named as VM Capacity-Aware Scheduling implemented the jobs within given a budget, at the same time reducing the slow down due to the budget constraints. In [10], a Task Scheduling with error Tolerance in Grid Computing using Ant Colony

Optimization was proposed to ensure that the tasks were implemented even when amen- ity error had occurred. This algorithm showed an improvement in the user's QoS over the existing ACO algorithm by making the use of the performance metrics: throughput and average turnaround time. In [11] paper focuses on solving VM placement problem with respect to the available frequency which is formulated as variable sized bin packing prob- lem. Moreover, a new frequency allocation policy is developed and hybridized with a developed various of whale optimization algorithm (WOA) called improved Levy based whale optimization algorithm. Cloudsim toolkit is used in order to test the validity of the proposed algorithm on 25 various data sets that generated in various and compared with diferent optimization algorithms including: WOA, frst ft, best ft, particle swarm optimization, genetic algorithm, and intelligent tuned harmony search.

In [12], the capabilities of the Taguchi method and the Diferential Evolution Algorithm (DEA) were combined into a newly proposed algorithm called the Improved Diferen- tial Evolution Algorithm (IDEA). IDEA was presented so as to optimize the scheduling of tasks and allocation of resources in the cloud environment. Cost and time models are depicted in order to evaluated the costs and time during task scheduling. The performance and receiving cost is included in the cost model and the processing time, receiving time and waiting time is included in the time model. In [13] proposed a demanding task to find appropriate commutation among resource utilization, energy consumption, and Quality of service (QoS). Taking into account of both processing time and transmission time a Particle Swarm Optimization (PSO) based Adaptive Multi-Objective Task Scheduling -AMTS Strategy is proposed in this paper. It is carried out by formulation of task scheduling

followed by advancement of scheduling policy to produce ideal resource utilization, task completion time, average cost, and average energy consumption. To maintain particle vari- ant adaptive acceleration coefcient is adopted.

In [14], Infrastructure as a Service (IaaS) is a service model that delivers computer infrastructure on a outsourced basis to support enterprise operations. It ofers many benefts to create efective cost and easily scalable IT solutions. While maintaining the Qual- ity of service (QoS) challenge arises on scheduling the task on peak demand. Proactive machine purchasing or cloud federation proposed previously is not economic and hardly feasible in practise and also requires an inter cloud-agreement. So a resource allocation framework is proposed where IaaS provider can outsource the tasks to External Clouds (EC's) when required to meet the challenge. The core issue is maximizing the proft of IaaS

and guarantee QoS by allocating resource accordingly. The problem is serviced as an Inte- ger Programming (IP) Model, and worked out by a Self-Adaptive Learning Particle Swarm

Optimization (SLPSO) based scheduling approach. In [15], Task scheduling plays a key role in cloud computing. The main reason behind scheduling tasks to the resources in accordance with the given time bound, which involves

fnding out a complete and best sequence in which various tasks can be executed by reduc- ing the makespan and cost to give the best and satisfactory result to the user. This paper put

forwards the task scheduling algorithm called W-Scheduler based on multi-criteria model and the whale optimization algorithm (WOA). It carries out its process by calculating the ftness value from the cost function of the central processing unit (CPU) and the memory.

Then the ftness value is calculated by summing up the makespan and the budget cost function. Thus, the whale optimization algorithm can optimally schedule the tasks to the virtual

machines by preserving the minimum makespan and cost. In [16] scheduling algorithm is necessary to optimize the VMs resources. Trade-of is

not usual in most algorithms. Modifed Fractional Grey Wolf Optimizer for Multi-Objec- tive Task Scheduling (MFGMTS) was proposed for use in cloud computing environment.

Objectives such as execution time, execution cost, communication time, communication

cost, energy consumption, and resource utilization are calculated by the usage of the epsilon-constraint and penalty cost function. The ftness function is reduced considerably. It

is an inspiration from the Fractional Grey-Wolf Optimization (FGWO). In [17], an algo- rithm based upon Ant-Colony optimisation is proposed called the MOSACO. The meas- urable network of the public and private resources of the VMs in hybrid clouds are used

to its best potential according to deadline and cost constraints. Features like completion time, time-frst cost, cost-frst single objective optimization, user QoS, etc. are increased to a great extent by the use of an entropy model. High level of optimization is provided by MASACO. In [18, 19] point out to multi-objective based scheduling like time, memory and cost. The above literature reviews did not provide near optimum result when performance, cost and deadline violation rate are considered together. This proposed method achieves a minimal makespan and cost among VMs as performance metrics to optimize task and resource, using a Cuckoo Search and Particle swarm

Optimization (CPSO) algorithm

based on the proposed models in cloud. The proposed scheduling hybridizes two algo- rithms namely cuckoo search algorithm (CSA) and Particle swarm Optimization (PSO).

This new hybrid algorithm optimizes the task and resources more efciently.

3 The problem definition and explanation

This paper describes the simple defnition of the system framework, tasks and the resources. The meaning and the primary parameters are listed below in Table 1. Firstly, in cloud computing of the current system assume there are N resources R=R1, R2,..., Rj , ..., Rn and K tasks T=T1, T2, ... Ti

, ... Tk and also the virtual resources are

referred as cloud resources. Defnition 1 (Resources) Each resources on cloud defned by utilization of both CPU and memory, that is Rj=(Cj ; Mj). Defnition 2 (Tasks) Ti=(Ci ; Mi ; Di ; Bi). The Ci and Mi

is the CPU and memory utiliza- tion of user submitted task. While Di

represents the task deadline, and Bi

represents the users budget cost. The task manager performs the tasks and the user submits the tasks.

Assumption 1 To proceed with the research, it is important to provide related assump- tions for the defnitions above mentioned. It is assumed that all the information submitted by the user is very accurate and also the information related to the resource demand is trusted. In cloud computing, the resource usage is monitored via virtualization technology. During the process, the number of users exceeding while applying for the process implementation is performed by user-accessed resources such as the CPU and memory. During the implementation, the tasks may fail in case if the system cuts-of the task performance. Therefore, Assumption 1 is reasonable.

There are numbers of users where the tasks are submitted to the task manager to accept and manage the task information. This task manager submits tasks via budget, cost, memory, and deadline. Then, the tasks are scheduled and mapped by the scheduler. It is mapped through the resources of tasks. These are mapped via the global resource manager. Global Table 1 Notations used in proposed CPSO task scheduling Symbol Defnitions Ti The task i, 1¡j¡K Uj The resource j, l¡i¡K N,K The amount of resources and tasks Ci , Mi CPU and memory of t Di The deadline of task T Bi The budget cost of task T Cj , Mj CPU and memory of Ri

Ccost(j), Mcost(j) The costs of CPU and memory of Ri

Cbase The base cost of CPUs lowest utilization

Mbase The base cost of memory under 1 GB memory

Tij The duration time of task T1 in resource Ri

CTransmission, MTransmission The transmission cost associated with CPU and memory Dv The deadline violation rate

Nd The number violating the deadline time in K tasks

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resource manager controls the resources globally. It is used to collect the cloud resource. The global resource manager monitors the time duration task on the resource. In addition to this process, it also calculates the cost of the resource. The overall process is done in cloud. This cloud allows the various physical nodes. There are also local resource manager for the servers. Each local resource manager allows various virtual machines. The cloud provides overall control of the physical nodes and the local resource manager's.

3.1 The system model

Our results add further evidence supporting the effectiveness of using competitive coevolution to create solutions to problems in AI. We consistently saw the fitness improve thoughout each trial. For example, early successful phenotypes tended to compete in a mad dash to the flag in the center. Later on, we saw both robots become more patient and hesitate before going for the flag. Another strategy was to wait for the opponent to obtain the flag before "capturing the flag" and resetting their position. Further testing with longer trial runs may yield more interesting and unforseen strategies and the development of complex strategies falls in line with the current research [**?**]. Initially the robots develop simple strategies corresponding to few nodes and connections. Building off of these networks creates foundations for more creatively complex strategies.
Overall, we believe that our experiments were successful in developing adaptive strategies without the need to hard-code functions to determine motor output. If we are able to run more generations and develop better topologies, we may see the rise of robots that can reasonably compete against a human-controlled opponent. We could then evaluate and evolve the robots based on interactions with humans, and reveal insights into human tendencies for strategies in the game. We believe that competitive coevolution should be applied to other challenged in AI development outside of the Pyrobot simulation.

4 Resource Cost and Task Scheduling Models

The relation between the user budget and cost of the resources from the resource cost model is depicted in the below given section. The multi-objective optimization scheduling model is built upon the resource cost model so as to optimize scheduling in the cloud.

4.1 The Resource Cost Model

In cloud computing, Tasks are of diferent natured either it can be more of CPU or storage utilized. In addition to it, the costs for diferent resources vary with each other; accordingly, task costs are also diferent. The diferent between the various task demands for each resource is considered to obtain connection between resource cost and user budget cost. Into rectify the problem, the resource cost model is used by dividing the resource cost into
CPU and memory accordingly to resource defnition Formula 1 defnes the cost of CPU. Here, Cbase defnes the base cost of resource's lowest utilization.tij defnes the time duration
of the task Ti run time of the task in resource Rj
. CTransmission defnes the CPU transmission
associated with the cost. Formula (2) defnes the memory cost. Similarly, Mbase represents the base cost while the memory space is 1 GB. tij represents the
time duration of the task Time

running in resource Rj
. MTransmissions represents the memory trans- mission of the associated cost. Formula (3) and formula (4) represents the cost model of CPU
and memory which are obtained from the cost functions.

5 Particle Swarm Optimization