A REVIEW ON HYBRID APPROACHES OF SCHEDULING IN CLOUD COMPUTING

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ABSTRACT: The advancement in the technology of cloud computing offers a wide range of services with attractive features like on-demand, self provisioning, resource sharing and pay on use models. The effective utilization of computing resources at cloud datacenter is challenging with reducing the execution time while delivering the Quality of Service (Qos) and also minimizing cost according to market challenges. Therefore, an optimal scheduling algorithm is needed to fulfill these requirements, which act as a main concern in cloud computing environment. In this paper, various scheduling approaches are discussed with their research outcomes. This study is made on different hybrid approaches used for improving the scheduling approaches in cloud computing which helps in identifying the useful features of the used algorithm. This study also describes the various hybrid algorithms and provides an analysis on objectives, QoS parameters and future directions.

Keywords: On-demand, resource sharing, self provisioning, cloud computing, hybrid approach

INTRODUCTION TO CLOUD COMPUTING

Cloud Computing is a trending advancement in the era of internet based computing which provides vast services on network. Cloud computing services are provided as on-demand services through various models such as pay-as-you-use and pay-as-you-go models. In cloud computing, services are accessed as information and virtual resources through network enabled computing system. These facilities make the cloud computing as a cost-based model providing more reliability, flexibility, scalability and achieve more integrity. Cloud resembles to utility based computing model. Cloud computing has become a highly required service due to the benefit of high computing performance, cash equivalents, high performance, availability, scalability along with accessibility. There are many cloud service providers experiencing additional growth rates each year due to the increase in the demand for cloud services, however being still during a stage of inception, it might face a risk that need to be targeted to create cloud computing services more reliable, efficient, economical and user friendly.

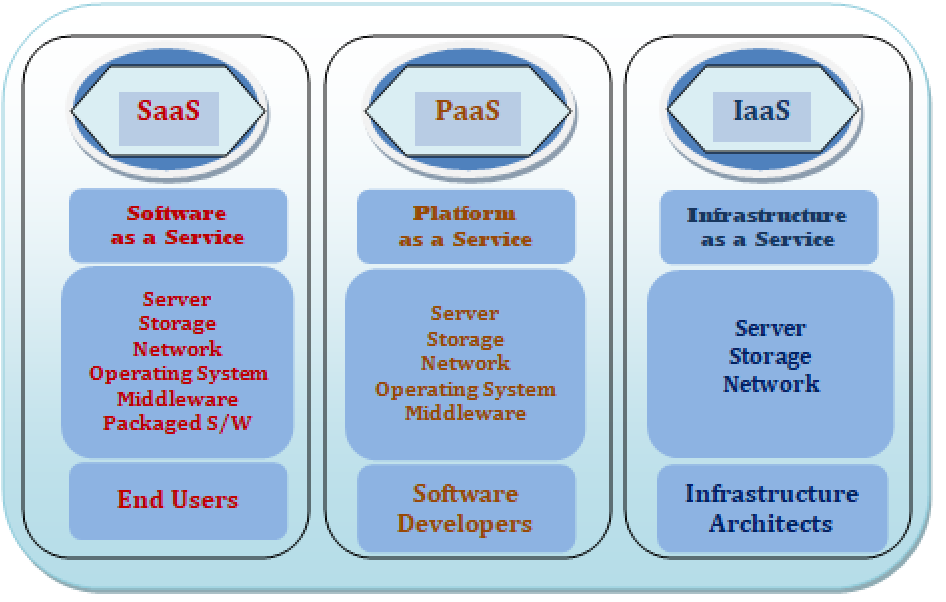

Figure 1- cloud computing services

Cloud resources at the datacenter with an under utilization rate, consumes an unsatisfactory amount of energy in comparison with the energy consumption rate of a completely utilized computing resources. The consumption of energy of idle resources is about 60% or more [1]. In cloud computing, there is an interconnection between energy consumption and utilization of resources. A powerful approach is Task consolidation that is distinctly enabled with the help of virtualization technologies, which support the concurrent execution of numerous tasks, harness the utilization of resource and reduce the consumption of energy [2].

OVERVIEW OF SCHEDULING IN CLOUD COMPUTING

The cloud services can be optimized with an effective resource scheduling algorithm for the task execution at the datacenter. Some of the parameters such as arrival time, execution time, time complexity and system requirements are considered in allocating resources to the task. The efficient resource scheduling at datacenter helps in improving the performance of cloud computing environment and ensures Quality of Service (QoS). This is achieved with maximizing the resource utilization and reducing resource idle time. Several QoS factors such as energy consumption, performance, resource utilization and time consumption are considered for allocating resources to the task execution [3]. The optimal resource scheduling algorithms are obtained by evaluating the performance by considering CPU, Memory and Network bandwidth to allocate resources more efficiently. The efficient scheduling of resources completes the task execution in time and assures a consumer with an improved flexibility and reliability in cloud systems [4]. The uncertainty of tasks can be overcome with better scheduling approach. Hence, scheduling is the primary concern in organizing cloud system to reduce execution time, minimize cost and maximize utilization of resources. The most commonly used objectives for scheduling strategy are based on QoS, Energy Efficiency, Time, Cost and Fault Tolerance [5].

Levels of Resource Scheduling in Cloud Computing

Scheduling of resources can be performed in two levels:

i. Virtual Machine (VM) – level.

ii. Host – level.

In Virtual Machine (VM) - level, task scheduling is performed by mapping the tasks for execution with allocated VMs using task scheduler. In host-level, VM Scheduling is performed by using VM scheduler to allocate the VMs into physical hardware [6].

The efficient mapping of appropriate resources like VMs is done using task scheduling. Depending on the task requirement, tasks are divided into independent and dependent tasks. The independent tasks are not dependent on any other tasks and during the scheduling process order of priority is not followed. Although, the dependent tasks have priority in order depending on dependencies between various tasks which are followed during the scheduling process. This type of dependent tasks scheduling is called as Workflow Scheduling.

In cloud environment, the suitable scheduling strategy is decided primarily on the basis of task requirement specifications. The main goal of selecting appropriate scheduling strategy is to reduce the makespan. In dependent task, the makespan can be reduced by minimizing the execution cost in each node and response time for transferring data between two nodes. In a case of independent tasks, they are scheduled independently without any complexities [7]. In VM scheduling, the allocation of VMs are done for the execution of tasks on Physical Machines and these VMs run on the appropriate Physical Machines (PMs). This improves resource utilization and maintains the load on each machine of the system. This type of scheduling facilitates the Quality of Service (QoS) and Service Level Agreements (SLA) between the cloud service providers and service consumers [8].

LITERATURE SURVEY

In [9], a hybrid discrete particle swarm optimization (HDPSO) algorithm is proposed based on discrete particle swarm algorithm and hill-climbing algorithm. This algorithm works in three phases. In a first phase, swarm members are produced by applying random algorithm followed by novel theorems. In a second phase, the result of first is provided as input for the new discrete particle swarm optimization (DPSO) algorithm and finally in the third phase to improve overall performance, hill-climbing algorithm for local search is used to avoid getting stuck in sub-optimal trap and to balance between exploration and exploitation. This work resulted in attaining an objective of minimizing the makespan. The HDPSO performed better in schedule length ratio (SLR), Speed-Up, and efficiency than the other exiting heuristics approaches and meta-heuristics approaches like GA, PSO.

In [10], a hybrid bio-inspired algorithm for task scheduling and resource management is presented by combining modified PSO and modified CSO algorithm. This hybrid approach reduces the average response time and increases the utilization of resources compared to round robin (RR), modified particle swarm optimization (MPSO), modified cat swarm optimization (MCSO), Ant Colony Optimization (ACO), and Exact algorithm. Python Simulator, PySim is used for the evaluation and validating the results. In future, dynamic scheduling is considered in which tasks will enter the cloud with different inter-arrival times.

In. [11], a hybrid approach named QMPSO algorithm for load balancing in cloud computing is proposed by combining modified particle swarm optimization (MPSO) and improved the Q-learning algorithm. The improved Q-learning algorithm is used to tune the velocity in MPSO algorithm resulting in attaining the objectives to optimize the makespan, throughput and energy utilization. The cloud simulator (CloudSim 3.0.3) is used for evaluation by submitting dependent tasks for execution resulting in reduced waiting time with reference to the combination of MPSO and Q-learning algorithms. In future, independent tasks can be considered for the implementation.

In [12], a hybrid electro search with a genetic algorithm (HESGA) is proposed by combining genetic algorithm (GA) and electro search (ES) algorithm. The proposed algorithm consists of four phases namely initialization, atom spreading, orbital transition and nucleus relocation. This approach optimizes makespan, execution time, and cost. In this combinational approach, the GA is used to achieve the local optimization results while the global results are achieved through electro search algorithm. The Cloud Simulator, CloudSim 3.0.3 is used for evaluation and outperforms GA, ES, ACO and HPSOGA (hybrid particle swarm optimization genetic algorithm) approaches. In future work, the degree of imbalance and energy efficiency concerns is evaluated by considering the dependency of tasks and scientific workflow.

In [13], a hybrid algorithm with two popular heterogeneous earliest finishes time (HEFT) and GA algorithms, named hybrid of HEFT and GA (HEFT-GA) is proposed by considering the task dependency. The HEFT approach is used to initialize the initial population of GA. The real work scientific workflows such as Montage, Cybershake, Epigenomics, Laser interferometer gravitational-wave observatory (LIGO), and sRNA identification protocol using high- throughput technologies (SIPHT) are evaluated in HEFTFA to optimize execution time and cost by using workflowsim simulator. In future work, power consumption problems at the datacenter are considered when planning workflows in cloud environment.

In [14], a hybrid genetic-gravitational search algorithm (HG-GSA) is proposed by combining the genetic algorithm with the gravitational search algorithm by storing the best particle position to overcome the drawback of gravitational search. In this approach, parallel computation is supported with new gravitational constant based on the particle best and global best values and including best position storage capabilities for selection of the next particle. Compared to PSO, Cloud-GSA, and linear improved GSA (LIGSA-C) approaches, the proposed algorithm reduces the total cost and increases resource utilization. CloudSim 3.0.3 simulator is used for evaluation. In future work, focus will be provided on the new hybrid algorithm based on the bio-inspired heuristics and center of mass-based crossover and diversity-based crossover techniques to reduce costs.

In [15], a multi objective task scheduling using hybrid approach named whale genetic optimization algorithm is proposed by combining whale optimization algorithm (WOA) and GA to optimize makespan and cost, enactment amelioration rate (EAR). This approach works in three modules. In first module, a policies module, which consists of scheduling process are applied that are set by cloud providers. In second module, objective/fitness function module, determines and evaluates the order and quality of a schedule. Finally, in third module, allocation of tasks to the resources using hybrid WGOA scheduling approach is done.

The main objective is to use WOA first and update the worst chromosome with GA operations like crossover and mutation. CloudSim simulator is used for the evaluation of this approach which in comparison to other standard algorithms such as FCFS, Min-Min, and Max-Min algorithm delivered optimized results. In addition, it is also compared with GA and WOA with better performance. In future, other parameters such as energy consumption issues, security and reliability can be considered.

In [16], a hybrid approach based deadline constrained, dynamic VM provisioning, and load balancing (HDD-PLB) algorithm is proposed by evaluating two proposed hybrid algorithms called predict earliest finish time-ACO (PEFT-ACO) and heterogeneous earliest finish time-ACO (HEFT-ACO). Cloud Workflow Simulator is used for simulation with PEFT-ACO, the hybridization of predict earliest finish time (PEFT) heuristics and ant colony optimization (ACO) and HEFT-ACO, the hybridization of Heterogeneous Earliest Finish Time (PEFT) heuristics and ant colony optimization (ACO). The objectives attained with this approach are makespan and cost. The work concludes that the approach PEFT-ACO proposed for HDD-PLB provides optimal output for CyperShake and LIGO workflow.

In [17], a hybrid scheduling algorithm using improved max-min and ACO algorithm proposed for balancing the load in cloud computing. The main goal of this study is to minimize the makespan and resulted with improved total processing time and processing cost with respect to basic max-min algorithm. The evaluation of proposed hybrid algorithm is done with CloudSim. In future, cost model can be considered and same work can be carried out with real time cloud environment.

In [18], a hybrid heuristic of variable neighborhood descent and great deluge algorithm for efficient task scheduling in grid computing is proposed by combining great deluge (GD) algorithm and variable neighborhood descent (VND) algorithm for scheduling independent tasks with a main goal of minimizing the makespan. The proposed algorithm was simulated on grid simulator to obtain optimal solution by achieving efficient and effective makespan and execution time. In future, resource entities with dynamic processing power can be created with the improvements in grid simulator.

In [19], a hybrid algorithm for multi-objective scientific workflow scheduling in IaaS cloud is rposed by combining genetic algorithm (GA) and artificial bee colony (ABC), to solve workflow scheduling problem. In this approach, scheduling is performed in two phases. GA is used to generate chromosome in first phase and passed to ABC algorithm to optimize the workflow and cost. Improved version of CloudSim, WorkflowSim-1.0 is used for evaluation of this approach and also some existing algorithms like multi-objective ACO (PBACO), hybrid multi-objective PSO (HPSO), multi-objective GA (MGA), multi-objective artificial bee colony (MABC), and heterogeneous earliest finish time (HEFT). The four well-known scientific workflows, such as Montage, LIGO, CyberShake, and Sipht are considered to get overall better performance for the proposed algorithm.

In [20], a hybrid job scheduling algorithm based on Tabu and Harmony Search algorithm is proposed by combining two popular bio-inspired algorithms such as tabu search (TS) and harmony search (HS) algorithms. The global optimization is achieved from harmony search algorithm and previously searched results are memorized using tabu search to avoid repetition and resulting in optimizing the throughput, makespan and cost. CloudSim V 4.0.3 is used for evaluation and found THTS approach is better with respect to tabu, harmony and round robin algorithms. In future, more complex dependent tasks like scientific workflows can be considered for implementation.

In [21], a hybrid moth search algorithm and differential evolution approach is proposed by combing the features of differential evolution (DE) and moth search (MS) algorithms. In this approach, differential evolution (DE) used to improve the exploration ability of the moth search algorithm (MS). The main goal of this approach is to divide the population into half depending on the fitness value and later apply differential evolution (DE) algorithm to improve exploration ability of the MS algorithm. This approach resulted in reducing the makespan in comparison to existing heuristic approaches such as SJF and RR and some meta-heuristic approaches like PSO, Whale Optimization Algorithm (WOA), and moth search algorithm (MSA). In future, more than one objective can be considered to evaluation and also workflow schedule can be viewed with other QoS factors such as memory utilization, demand and overload of resources.

In [22], a GSA based hybrid algorithm for bi-objective workflow scheduling is proposed by considering a gravitational search algorithm (GSA) with heterogeneous earliest finish time (HEFT) algorithms. This approach is mentioned as bi-objective since it focuses on two objectives namely makespan and cost. This approach is implemented using C++ coding environment for simulation. They considered monetary cost ratio (MCR) and schedule length ratio (SLR) to show that the proposed approach is better in performance compared to standard GSA, hybrid genetic algorithm (HGA), and the HEFT. The evaluation of this approach is done with five popular scientific workflows such as CyberShake, LIGO, Montage, SIPHT, and Inspiral and at last validated the results using the ANOVA statistical test. In future, during the simulation, available bandwidth between the VM can be considered as variable and VM failure will be considered during the execution of task.

In [23], a hybrid meta-heuristic for multi-objective scientific workflow scheduling is proposed by combining symbiotic organisms search (SOS) and predicts earliest finish time (PEFT) algorithms to solve scientific workflow in cloud environment. The scientific workflows such as Montage, LIGO, SIPHT, CyberShake, and Epigenomics are used for scheduling simulation. The predicted earliest finish time (PEFT) algorithm is used to increase global exploration ability of symbiotic organisms search (SOS) which enhances the convergence rate and diversity regarding true Pareto optimal front. The main goal of the proposed approach is to optimize the makespan and cost and outperformed in comparison to MOHEFT, MOPSO, NSGA-II. In future, energy consumption factor and CO2 emission concerns are considered for optimization

Table 1: Details of scheduling approaches in cloud computing

Scheduling Approach	Combination Used	Parameters used	Tools used	Objectives Achieved	Task Type
Hybrid Discrete Particle Swarm Optimization (HDPSO) Algorithm [9]	Random, DPSO, Hill Climbing	SLR, Speed-up Efficiency	Mathematical workflows, LU, GJ and FFT Graphs	Makespan, Cost	Dependent
Hybrid Bio-Inspired algorithm [10]	Modified PSO, Modified CSO	Resource Utilization, Reliability, Response time	PySim	Response time, Resource Utilization	Dependent
QMPSO for load balancing in cloud computing [11]	Modified PSO, Q-Learning	Makespan, Throughput, Waiting time, Energy Utilization	CloudSim	Makespan, Throughput, Energy Consumption	Dependent
Hybrid Electro Search with a Genetic Algorithm (HESGA) [12]	Genetic, Electro Search	Makespan, Load balancing, Resource utilization, Cost	CloudSim	Makespan, Cost, Execution Time	Dependent
Heterogeneous earliest finish time (HEFT) and GA algorithms (HEFTGA) [13]	Hybrid Earliest Finish Time, Genetic	Makespan, Cost, Deadline	WorkflowSim, Java, Netbeans IDE	Makespan, Cost, Time	Dependent
Hybrid Genetic-Gravitational Search Algorithm (HG-GSA) [14]	Genetic Gravitational Search	Cost, Execution time, Transfer time, Resource Utilization	CloudSim	Cost, Resource Utilization	Dependent
Hybrid Whale Genetic Optimization Algorithm [15]	Whale Optimization, Genetic	Makespan, Cost, Enactment Amelioration Rate (EAR)	CloudSim	Makespan, Cost, Execution time	Independent
Hybrid approach based Deadline constrained, dynamic VM provisioning, and load balancing (HDD-PLB) [16]	Predict Earliest Finish Time-ACO (PEFT-ACO), Heterogeneous Earliest Finish Time-ACO (HEFT-ACO)	Load Balancing, Resource utilization, Cost, Execution time	WorkflowSim	Makespan, Cost	Independent

Dynamic Combination of Improved Max-Min and Ant Colony Algorithm [17]	Max-Min, Ant Colony Optimization	Load balancing, Makespan, Execution time, Cost	CloudSim	Makespan, Cost	Independent
hybrid heuristic-based great deluge (GD) and variable neighborhood descent (VND) algorithm, (GDVND) [18]	Great Deluge, Variable Neighborhood Descent	Execution time, Makespan, Cost	GridSim, Java, Eclipse IDE	Makespan	Independent
Hybrid Genetic Algorithm and Artificial Bee Colony (HGAABC) [19]	Genetic, Artificial Bee Colony	Makespan, Cost	WorkflowSim	Makespan, Cost	Independent / Dependent
Hybrid Tabu-Harmony Task Scheduling Algorithm (THTS) [20]	Tabu search (TS), Harmony search (HS)	Bandwidth, Execution time, Cost	CloudSim	Throughput, Makespan, Cost	Independent
Hybrid Moth Search and Differential Evolution Algorithm (MSDE) [21]	Moth search algorithm (MSA), Differential Evolution (DE)	Bandwidth, Makespan	CloudSim	Throughput, Makespan	Independent
GSA Based Hybrid Algorithm for Bi-Objective Workflow Scheduling [22]	Gravitational Search Algorithm, Heterogeneous Earliest Finish Time	monetary cost ratio (MCR), schedule length ratio (SLR)	C++, ANOVA	Makespan, Cost	Independent / Dependent
Hybrid Bio-inspired Meta-heuristic for Multi-objective Optimization (HBMMO) [23]	Symbiotic Organisms Search (SOS), Predicted Earliest Finish Time (PEFT)	Load balancing, Makespan, Cost	WorkflowSim, ANOVA	Makespan, Cost, Resource utilization	Independent / Dependent

CONCLUSION

The cloud computing offers numerous on-demand self-provisioning services through its service models. The Scheduling is used to provide Quality of Service and to reach service consumers on time by executing the task submitted with a better performance. In this paper, various hybrid scheduling approaches are studied for their efficiency and performance in completing a task with accuracy and correctness. The study on various approaches helps in identifying the different parameters which can be considered in improving the scheduling algorithms for better performance and enhanced Quality of services while delivering the cloud services to end users. In Future, many more multi objectives approaches of hybrid algorithms can be studies with dependent and independent tasks. These hybrid approaches can be implemented with real world cloud environment with various combinations of meta-heuristics algorithms.

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