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Green cloud environment by using robust planning algorithm

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A B S T R A C T

Cloud computing provided a framework for seamless access to resources through network. Access to resources is quantified through SLA between service providers and users. Service provider tries to best exploit their resources and reduce idle times of the resources. Growing energy concerns further makes the life of service providers miserable. User's requests are served by allocating users tasks to resources in Clouds and Grid environment through scheduling algorithms and planning algorithms. With only few Planning algorithms in existence rarely planning and scheduling algorithms are differentiated. This paper proposes a robust hybrid planning algorithm, Robust Heterogeneous-Earliest-Finish-Time (RHEFT)[1] for binding tasks to VMs. The allocation of tasks to VMs is based on a novel task matching algorithm called Interior Scheduling. The consistent performance of proposed RHEFT algorithm is compared with Heterogeneous-Earliest-Finish-Time (HEFT)[2] and Distributed HEFT (DHEFT)[3] for various parameters like utilization ratio, makespan, Speed-up and Energy Consumption. RHEFT's consistent performance against HEFT and DHEFT has established the robustness of the hybrid planning algorithm through rigorous simulations.

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1. Introduction

Diverse resources with varied capabilities and connected through high speed interconnecting network provides new platform for distributed processing. Cloud and Grid computing evolved from such aggregation of resources. These are primarily maintained by service providers (Amazon, IBM, Microsoft, etc). Users subscribe for services from these platforms and submit their tasks for processing. Users are served by allocating their tasks to various resources and executing them. When tasks executions times, inter-task dependencies and inter-task data transfer size is known then such task model is called static model. User's submissions are processed in clouds by subjecting tasks to resources. Resource usage in clouds depends upon the types and sequence of tasks and resources. Work flow technologies are used to deal with increasing complex data, data-intensive application, simulations and analysis. These technologies are also used to schedule computational tasks on distributed resources, to manage dependencies among tasks and to stage data sets into and out of execution sites [8]. These workflows are used to model computations in many scientific disciplines [9].

A number of task scheduling algorithm are proposed in literature which are broadly classified into list-scheduling algorithms, level-by-level scheduling, batch scheduling, duplication based scheduling, dependency scheduling, batch dependency scheduling algorithm, Genetic Algorithm (GA) based scheduling algorithms and hybrid algorithm. List scheduling algorithm creates a list of task while respecting task dependency. Tasks in list are processed in order of their appearance in the task list. The performance of such algorithm is comparatively better than other categories of algorithms. Level-by-level scheduling algorithms consider tasks of one level in task-graph such that task considered are independent of each other. This set of tasks may not include all the tasks in ready queue. In Genetic algorithm based solution schedules are reasonably acceptable but the computational complexity of algorithm is relatively high. Hybrid algorithm explores various combinations of existing classes of scheduling algorithms.

Task scheduling in heterogeneous systems is considered in Het erogeneous-Earliest-Finish-Time (HEFT) [7], Duplication based HEFT [21] and Deadline–Budget Constrained Scheduling (DBCS)

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[1] Robust Heterogeneous-Earliest-Finish-Time (RHEFT).
[2] Heterogeneous-Earliest-Finish-Time (HEFT).
[3] Distributed HEFT (DHEFT).

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[4]. In HEFT [7], authors proposed a ranking of tasks on the basis of bandwidth, task's length, and parent-child relationships. Tasks are considered for execution in order of their rank in decreasing order. Duplication based HEFT used the concept of task duplication and utilized the free cycles of VMs for execution of duplicate tasks. Distributed HEFT (DHEFT) exploits the concept of distributed approach and better exploits the concept of VM level availability for better task-VM mappings [20]. This paper proposes a variant of HEFT called Robust HEFT (RHEFT) by using a hybrid approach and a novel scheduling algorithm for set of independent tasks. Tasks are ranked as per ranking method of HEFT, which is followed by grouping of free tasks into same group. Groups are processed in order of their creation. Tasks in a group are processed such that scheduling reduces the variance in difference of task's execution time and VM's mean execution time. Section 2 presents the related works, Section 3 presents the preliminary. Section 4 presents Interior Scheduling (IS) and RHEFT algorithm. Section 5 presents simulation set-up and performance discussion. Finally, concluded in Section 6 with a future direction.

2. Related works

This section presents a brief review of several research works done in the field of scheduling. Research work in [10–15,8,14] proposed scheduling solutions for workflows. Work in [15,18,17,19,5,1] refers to solution for independent tasks. [4,7] presents scheduling algorithms for heterogeneous systems. [3] presents a taxonomy of scheduling of tasks in clouds and grids.

Research work in [8], provided multiple scientific applications including astronomy, bioinformatics, earthquake science, and gravitational-wave physics is based on novel workflow profiling tools that provide detailed information (includes I/O, memory and computational characteristics) about various computational tasks that are present in the workflow. In [10], authors described an extension to Pegasus whereby resource allocation decisions are revised and described how adaptive processing has been retrofitted to an existing workflow management system; a scheduling algorithm that allocates resources based on runtime performance. The results were evaluated using grid middleware over clusters. In [11], authors proposed a dynamic critical-path-based adaptive workflow scheduling algorithm for grids, which determines efficient mapping of workflow tasks to grid resources dynamically by calculating the critical path in the workflow task graph at every step. In [12], authors designed and analyzed a two-phase scheduling algorithm for utility Grids, called Partial Critical Paths (PCP), that was used to minimize the cost of workflow execution while meeting a user defined deadline and also proposed two workflow scheduling algorithms one was one-phase algorithm which is called IaaS Cloud Partial Critical Paths (IC-PCP), and a two-phase algorithm which is called IaaS Cloud Partial Critical Paths with Deadline Distribution (IC-PCPD2) that have a polynomial time complexity which make them suitable options for scheduling large workflows. Work in [13], proposed a new dynamic task scheduling algorithm for Heterogeneous environments called Clustering Based HEFT with Duplication (CBHD). The CBHD algorithm is considered an amalgamation between the most two important task scheduling in Heterogeneous machine, The Heterogeneous Earliest Finish Time (HEFT) and the Triplet Clustering algorithms. CBHD outperforms the HEFT and Triplet algorithm by decreasing the makespan by 2.5%. It also achieves better load balancing than the HEFT algorithm by 70%, and it increases processors utilization by 10% with respect to the HEFT and Triplet algorithms. In [14], the authors presented a Hybrid Cloud Optimized Cost scheduling algorithm that decides which resources should be leased from the public cloud and aggregated to the private cloud to reduce costs while achieving the established desired execution time. HCOC tried to optimize the monetary execution costs while maintaining the execution time lower than Deadline.

In [15], authors proposed a novel heuristic for scheduling of set of independent tasks, called Balanced Minimum Completion Time (BMCT). First phase performs initial allocation using FCFS. In next phase BMCT tries to minimize the complete execution time by swapping tasks between machines. This results in balancing of load among the machines. BMCT has shown promising results when compared with Dynamic Level Scheduling (DLS) [16], Heterogeneous Earliest Finish Time (HEFT) [7]; Critical Path On a Processor (CPOP) [7] etc. under consistent heterogeneous, partially consistent heterogeneous and inconsistent heterogeneous environments. In [5], presented multi-objective PSO based optimization algorithm for dynamic environment of clouds and optimize energy and processing time. Proposed algorithm provides an optimal balance results for multiple objectives. The experimental results illustrated that the proposed methods out-performed the Best Resource Scheduling (BRS) and Random Selection Algorithm (RSA). In [17], authors proposed, two task scheduling algorithm namely user-Priority Awarded Load Balance Improved Min-Min Scheduling Algorithm (PA-LBIMM) and Load Balance Improved Min-Min (LBIMM) scheduling algorithm were proposed with objectives to decrease job's completion time, improve the load balance and satisfy users' priority demands in the cloud. LBIMM performs in two phases namely first phase is min-min and second phase is preemption of smaller tasks from heavenly loaded resources and migrate them to resources with fastest completion time for preempted job. In PA-LBIMM tasks are divided into two groups based high or low priority. Initially, allocation is done to tasks with higher priority and then tasks of lower priority are allocated to resources. Initial allocation is realized through Min-Min scheduling algorithm. In Next phase load balancing based on preemption of tasks is performed. Result reported in paper proves that PALBIMM and LBIMM outperform the Min-Min algorithm in all aspects. In [1], authors proposed an energy efficient scheduling algorithm, (EEVS) considering the deadline constraint. EEVS can support DVFS well. From the computation of total energy of a PM, authors conclude that there is an optimal frequency for it to process certain VMs. Based on the optimal frequency; authors define the optimal performance–power ratio to weight the heterogeneities of the PMs. The PM with highest optimal performance–power ratio will be used to process the VMs first unless it does not have enough computation resources. Finally the cloud should be reconfigured to consolidate the computation resources of the PMs to further reduce the energy consumption. EEVS consumes less energy and processes more VMs successfully than the existing methods. In [4], presented a heuristic scheduling algorithm with quadratic time complexity that considers two important constraints for QoS-based workflow scheduling, time and cost, named Deadline–Budget Constrained Scheduling (DBCS) for heterogeneous systems. DBCS has the lowest time complexity (quadratic time complexity), while other algorithms mostly have cubic or polynomial time complexities. In terms of the quality of results, DBCS achieves rates of successful schedules similar to higher-time complexity algorithms for both random and real application workflows on diverse platforms.

In [18], authors presented two novel dynamic scheduling algorithms for heterogeneous and federated cloud system. The objective was to achieve resource optimization mechanism for preempt-able applications in autonomous heterogeneous cloud environment. Authors also proposed a dynamic procedure with updated information. The procedure helped to achieve considerable improvement in resource utilization and energy efficiency in any given resource contentious environment. In [19], authors had presented a thorough review of workflow scheduling algorithms under different classes. Authors proposed a paradigm to classify the exist-

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