Efficient Job Scheduling in Computational Grid Systems Using Wind Driven Optimization Technique

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ABSTRACT

Computational Grid has been employed for solving complex and large computation-intensive problems with the help of geographically distributed, heterogeneous and dynamic resources. Job scheduling is a vital and challenging function of a computational Grid system. Job scheduler has to deal with many heterogeneous computational resources and to take decisions concerning the dynamic, efficient and effective execution of jobs. Optimization of the Grid performance is directly related with the efficiency of scheduling algorithm. To evaluate the efficiency of a scheduling algorithm, different parameters can be used, the most important of which are makespan and flowtime. In this paper, a very recent evolutionary heuristic algorithm known as Wind Driven Optimization (WDO) is used for efficiently allocating jobs to resources in a computational Grid system so that makespan and flowtime are minimized. In order to measure the efficacy of WDO, Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) are considered for comparison. This study proves that WDO produces best results.

KEYWORDS

Computational Grid, Flowtime, GA, Job Scheduling, Makespan, PSO, WDO

1. INTRODUCTION

Computational Grid computing system has been a well-known distributed computing platform for solving complex large-scale problems in science, engineering and finance. It consists of geographically distributed and heterogeneous networked resources owned and shared by multiple administrative organizations. A resource management system (RMS) is a crucial ingredient of the Grid system; it is responsible for discovery, controlling and supervising the usage of resources. It then performs the scheduling of incoming jobs, allocating them to available suitable resources. The job scheduling in such complex heterogeneous environment is one of the most challenging tasks. In other words, the optimal mapping of jobs to available resources in a Grid computing environment is an NP-complete problem and therefore the use of heuristics is one of the appropriate methods (Xhafa and Abraham, 2010).

Grid scheduling optimization criteria include: makespan, flowtime, resource utilization, load balancing, matching proximity, turnaround time, etc. Minimization of makespan and flowtime are the two most important criteria. Makespan represents the time when Grid finishes the latest job and flowtime represents the sum of finalization times of all the jobs. In this paper, a modern nature-

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inspired global optimization technique known as Wind Driven Optimization (WDO) has been employed to concurrently minimize two key performance parameters, viz. makespan and flowtime, of a computational Grid system. The WDO algorithm is compared with Genetic Algorithm (GA) (Braun et al., 2001) and Particle Swarm Optimization (PSO) (Salman et al., 2002) and is shown to produce the best results.

This paper is organized as follows. Section 2 highlights the relevant past works done on job scheduling in computational Grid environment. Section 3 defines the framework of Grid job scheduling problem. Sections 4 and 5 outline GA and PSO methods respectively. Section 6 describes WDO algorithm for scheduling jobs in computational Grid systems. Section 7 exhibits the results obtained in this study. Finally, Section 8 concludes the paper.

2. RELATED WORKS

Computational Grid is composed of a large number of heterogeneous resources and jobs, which are executing concurrently and are changing dynamically. Due to such environment characteristics, the job scheduling in Grid is an NP-complete problem. New approaches, particularly those based in heuristic algorithms, have been proposed to solve the Grid scheduling problems. These sorts of approaches make realistic assumptions based on a priori knowledge of the concerning environment and of the system load characteristics. The most frequently used heuristic algorithms are Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Simulated Annealing (SA), Ant Colony Optimization (ACO) and Cuckoo Search Algorithm (CSA). Genetic Algorithms (GAs) for Grid scheduling problems have been addressed by Abraham et al. (2000), Braun et al. (2001), Zomaya and Teh (2001), Martino and Milillo (2004), Page and Naughton (2005), Gao et al. (2005), Xhafa et al. (2008) and Aggarwal et al. (2005). Zhang et al. (2008) have applied Particle Swarm Optimization (PSO) algorithm for Grid scheduling and showed that PSO gives better results compared to GA. A fuzzy PSO algorithm for scheduling has been proposed by Abraham et al. (2010). Simulated Annealing (SA) is more powerful than simple local search by accepting poorer solutions with certain probability. Abraham et al. (2000), Goswami et al. (2011), and Yarkhan and Dongarra (2002) have studied SA technique for Grid scheduling. An Ant Colony Optimization (ACO) implementation for the scheduling problem under the ETC model has been addressed by Ritchie (2003). An ACO algorithm for dynamic job scheduling in Grid environment has also been investigated by Lorpunmanee et al. (2007). Prakash et al. (2012), and Rabiee and Sajedi (2013) have proposed a job scheduling in Grid using Cuckoo Search Algorithm (CSA). A large number of researches have been carried out using hybrid approaches. For example, Abraham et al. (2000) have proposed the hybridization of GA, SA and TS heuristics. Another hybrid method for the problem has been addressed by Ritchie and Levine (2004) who combine an ACO algorithm with a TS algorithm for the problem. Sajedi and Rabiee (2014) have combined CSA with GA for job scheduling in Grids. Pooranian et al. (2013) have proposed a new hybrid scheduling algorithm that combines GA and the Gravitational Emulation Local Search (GELS) algorithm.

3. PROBLEM DEFINITION

The job scheduling in Grid is an NP-complete problem, i.e., no such deterministic technique exists which can produce an optimum solution in polynomial time. In order to solve such problems, the heuristic methods have proven to be efficient (Xhafa and Abraham, 2010). For realistic simulations of job scheduling in Grid systems, simulation model of Ali et al. (2000) has been considered. In this model, it is assumed that an estimation of the computational needs of each job (in millions of instructions), the computing capacity of each resource (in millions of instructions per second, MIPS), and an estimated load of prior work of each resource are provided. All this information is contained in Expected Time to Compute (ETC) matrix of size $m \times n$ where, $m$ indicates the number of jobs and $n$ indicates the number of resources. Each row of the ETC matrix represents the estimated execution time
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