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Biogeography-based optimization for optimal job scheduling in cloud computing

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ABSTRACT

In cloud computing, the resources are dynamic and their performance or load can change frequently over time. Cloud resource management needs the functionality for NP-complete scheduling of jobs. The objective of this paper is to optimize the job scheduling using biogeography-based optimization (BBO). BBO migration is used to change existing solutions and to adapt new good solutions. BBO offers the advantage of adaptive process, which is developed for binary integer job scheduling problem in cloud computing. Experimental results show that the performance of the proposed methods are better than the considered other methods in job scheduling problems.

1. Introduction

Cloud computing is a large-scale distributed computing paradigm. It is the evolution of the traditional distributed computing and grid computing [1,2]. The computing resources available in cloud are highly dynamic and possibly heterogeneous. It differs from traditional distributed computing [3]. The computational resources are geographically distributed and are shared among jobs in cloud. Job scheduling is one of the important activities performed in grid and cloud computing environments, as its objective is to deliver available computing resources as services over networks [4,5]. Job scheduling is known to be NP-complete [6]. It is drawing researcher's attention worldwide because of its practical importance and its complexity [7,8]. Unfortunately, scheduling algorithms in traditional distributed computing cannot work well in cloud computing as its large-scale and dynamic.

Swarm intelligence is an innovative distributed intelligent paradigm whereby the intelligence that emerges in nature from the organic evolution and the collective behaviors of unsophisticated individuals interacting locally with their environment is exploited to develop optimization algorithms that identify optimum solutions efficiently in complex search spaces [9,10]. Within these paradigm algorithms have been developed that mimic organic evolution process or swarming behaviors observed in swarms of bees, colonies of ants, flocks of birds, and even human social behavior, from which intelligence is seen to emerge [11–13]. The population based algorithm can be classified into two major categories. The first is evolutionary algorithms, such as genetic algorithm (GA), simulated annealing (SA). The second is swarm intelligent based algorithms, such as

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artificial bee colony (ABC) and particle swarm optimization (PSO). These algorithms have been presented as a means of efficiently scheduling job in traditional distributed computing and grid computing [14,8,15].

Recently, Simon has proposed a novel biology based optimization method called biogeography-based optimization (BBO) and compared it with other population based optimization methods [16]. Simon has also mentioned that BBO has advantages for high-dimension problems [17]. We will discuss the related works and methodologies used in earlier studies in Section 2. Motivation of our study is to present BBO algorithms for job scheduling in cloud computing. First, we introduce the standard BBO for job scheduling as BBO1, which generates the valid solutions for initializing population. The BBO2 updates the solutions if new generated solution is better than old ones after migrating for converged search and mutating for diversified search.

The rest of the paper is organized as follows. Related works about job scheduling in distributed computing, grid computing and cloud computing environment is provided briefly in Section 2. We discuss the related theoretical foundations in Section 3. In Section 4, our proposed BBOs are described in detail. Experiment results and analysis are presented in Section 5 and some conclusions are provided towards the end.

2. Related work

Job scheduling is mapping a set of job to a set of resources to effectively and efficiently utilize the computing capabilities and storage capabilities of parallel system, large-scale cluster system, distributed system, grid and cloud. In the past decades, many researchers focus on job scheduling and a multitude of different algorithms have been proposed to solve this problem [18–20]. Due to the NP-complete of the problem, no feasible exact solutions are proposed. Therefore the approximation algorithms that are intent to find a near optimal solution are popular. Heuristic algorithms are suitable approach for solving NP-complete problem [21,22]. The most popular heuristic algorithms are genetic algorithm (GA) [23], simulated annealing (SA) [24], Particle swarm optimization (PSO) [25] and Artificial Bee Colony Optimization (ABC) [26].

Genetic algorithms based job scheduling approaches in distributed environments were studied by Hou [27] and Wang [28]. Hou [27] proposed a genetic algorithm for deterministic model based multiprocessor scheduling problem, in which the execution time and the relationship between jobs are known. Wang et al. [28] proposed a genetic algorithm based approach for job scheduling in heterogeneous computing environments, in which the tasks are decomposed into subtasks that have data dependencies. The proposed algorithm is effective to the static job scheduling. Liu et al. [14] proposed fuzzy particle swarm optimization and verified the performance of PSO compared with GA and SA. The approach to scheduling jobs in computational clouds is based on using fuzzy matrices to represent the position and velocity of the particles in PSO for mapping the job scheduling and the particle. The object function of the scheduling model is to complete the tasks in a minimum period of time as well as utilizing the resources. The performance of the fuzzy swarm optimization is better than that of GA and SA. Kim et al. [8] introduced an efficient binary artificial bee colony algorithm as an enhancement of binary artificial bee colony algorithm for solving the makespan minimization problem in grid computing job scheduling. They demonstrate theoretically that the algorithm converges with a probability of 1 towards the global optimal. However, the job scheduling in cloud is highly dynamic and massively scalable. The job scheduling algorithms in grid and traditional distributed systems cannot work well in cloud. It is necessary to explore effective and efficient algorithm for job scheduling in cloud.

Recently, Simon [16] provided a general presentation of the new optimization method called biogeography-based optimization (BBO). He compares and contrasts BBO with other population-based optimization methods. He also applies BBO to the real-world problem of sensor selection for aircraft engine health estimation. Simon [29] develops a Markov analysis of BBO, including the option of elitism. They also show that elitism is not necessary for all problems, but for some problems it can significantly improve performance. They use elitism in order to retain the best solutions in the population from one generation to the next. Simon [17] illustrated that BBO is a generalization of a GA/GUR (genetic algorithm with global uniform recombination) when immigration rate is 1. The authors of this paper mention that BBO outperforms genetic algorithm with global uniform recombination for all problem sizes and all population sizes. They also mention that BBO has advantages for high-dimension problems and with large populations and BBO performs significantly better than both GA with single-point crossover and GA/GUR for lower mutation rates. They found that BBO consistently performs much better on traveling salesman problem benchmarks, usually performs better on graph coloring benchmarks, and sometimes performs better on bin packing benchmarks. Ma [30] proposed the blended BBO that generally outperforms standard BBO on a set of benchmark problems. The offspring are obtained by combining parents' genes instead of copying a parent's gene to a child chromosome in blended crossover. A new solution feature in a BBO solution is comprised of two components that are the migration of features from another solution and itself. Roy [31] proposed BBO for solving constrained optimal power flow problems in power systems. In this paper, we present BBO algorithms for job scheduling in cloud computing effectively.

3. Problem definition

Cloud computing is a novel computation model, in which the resources are shared by using virtualization technologies over internet [32]. It makes required resources of job manifest in the form of a virtual machine. The open source