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Bio-Inspired Scheduling of High Performance Computing Applications in Cloud: A Review

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Abstract— **Cloud computing is a type of internet based computing that trusts sharing computing resources rather than having local servers or personal devices to handle applications. High performance computing applications are some scientific applications that require high bandwidth, low latency networking, and very high computing capabilities. Scheduling and managing high performance computing resources in cloud environment is an NP-Hard Problem. Many conventional algorithms were used by the researchers to solve this problem. Scheduling algorithms inspired by the social behaviour of colonies formed by organisms like Ant, Bees etc. have excellence in dealing with complex optimization problems and thereby opening a new era in computation. Still being young and the results being very amazing broadens the future scope of Bio-Inspired Algorithms (BIAs) exploring new areas of application and more opportunities in computing .This paper surveys the recent advances in biologically inspired swarm optimization methods including ant colony optimization algorithm, artificial bee colony algorithm, cuckoo search and particle swarm optimization algorithm**

Keywords— **Resource allocation, Bio inspired algorithms, Cloud computing, High Performance Computing**

I. INTRODUCTION

Today owing to consistently changing requirements of users and increase in demand of services and applications requiring huge processing power and heavy resources has led to the development of cloud computing technology wherein all high cost infra-structure and computational resources are installed in single datacenter. The Cloud service delivery models are categorized into three major types viz., Software as a Service (SaaS),Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) [1].In SaaS, software application is made available by the cloud provider. In PaaS an application development platform is provided as a service to the developer to create a web based application. In IaaS computing infrastructure is provided as a service to the requester in the form of Virtual Machine (VM).The importance of these services is highlighted in a recent report from Berkeley as: "Cloud computing, the long-held dream of computing as a utility, has the potential to transform a large part of the IT industry, making software even more attractive as a service" [2]. Cloud computing environments provide an illusion of infinite computing resources to cloud users so that they can increase or decrease their resource consumption rate according to the demands.

HPC applications are mainly focused on scientific applications that may fall into any one of the categories, specifically parallel, iterative parallel, embarrassingly parallel, data intensive and workflow applications. The HPC applications are complex in nature; they require large amounts of computational cycles that also involves vast amount of data processing.

II. RESOURCE ALLOCATION

In a cloud environment, computing resources are allocated when a user (or a user application) makes a request. The type and amount of resources to allocate are determined according to the user request and availability of the resource, and the user application (or its processes) is placed somewhere in the provider's data center. Resource allocation involves deciding what, how many, where, and when to make the resource available to the user. Typically, users decide the type and amount of the resource containers to request, and then providers place the requested resource containers onto nodes in their data centers. To run the application efficiently, the type of resource container need to be well matched to the workload characteristics, and the amount should be sufficient to meet the constraints (e.g., job completion time deadline).In an elastic environment like the Cloud where users can request or return resources dynamically, it is also important to consider when to make such adjustments.

III. SCHEDULING ALGORITHMS

Scheduling and managing high performance computing resources in cloud environment is an NP-Hard Problem. So we have to find an algorithm for getting a near optimal solution to this problem. The scheduling algorithms mainly focus on the distribution of the resources among the requestors that will maximize the QoS parameters. The scheduling algorithm is designed considering the tasks and the available virtual machines together to maximize the resource utilization.

Nature inspired algorithms receive their inspiration purely from nature. Even if hardly any knowledge of the research space is available, they can still describe and resolve complex relationships from essentially very simple initial conditions and rules. The perfect example for optimization can be cited in nature since a close examination of each and every phenomenon in nature reveals to us the optimal strategy of nature in confronting complex interactions among organisms ranging from microorganism to fully fledged human beings, balancing the ecosystem, maintaining diversity, adaptation, physical phenomena like river formation, forest fire, cloud, rain etc. The strategy behind the solution may look simple but the results are incredible leaving anyone amazed at the enormous and mysterious designs and capacities of nature. No wonder, researchers aspire to mimic nature in technology. Moreover, nature and technology may be said to be interconnected by reasonably thinking that new or persistent problems in computer science could have a lot in common with problems nature has come upon and resolved long ago. This brings in the possibility of an easy mapping between nature and technology. Bio inspired computing has brought about a new era in computing that encompasses a widespread variety of applications, covering virtually all areas including computer networks, security, robotics, bio medical engineering, control systems, parallel processing, data mining, power systems, production engineering and so on.

A. Ant Colony Optimization Algorithm

To solve difficult scheduling problem, a new approach has been proposed, which is inspired by the natural behavior of ant colonies. The objective of Ant Colony Optimization (ACO) [5] is to dynamically generate an optimal schedule so as to complete the tasks in minimum period of time as well as utilizing the resources in an efficient way. The first ACO algorithm was called the Ant system and it was aimed to solve the traveling salesman problem, in which the goal is to find the shortest round-trip to link a series of cities. The general algorithm is relatively simple and based on a set of ants, each making one of the possible round-trips along the cities. Real ants foraging for food lay down quantities of pheromone (chemical cues) marking the path that they follow. An isolated ant moves essentially at random but an ant encountering a previously laid pheromone will detect it and decide to Ant Algorithm for Grid Scheduling. The repetition of the above mechanism represents the auto catalytic behavior of real ant colony where the more the ants follow a trail, the more attractive that trail becomes [6]. It provides a real distributed real time system with no global control for schedulers. The resource allocation decision is not directly made by the grid system. The algorithm can adopt the system environment freely at runtime. It uses the previous information and allocates the resource optimally and adaptively in the scalable, dynamic and distribute controlled environment.

B. Artificial Bee Colony Algorithm

Artificial Bee Colony Optimization was proposed by Karaboga in 2005.In the artificial bee colony (ABC) algorithm [7], the colony of artificial bees comprises three groups of bees: employed bees, onlookers and scouts. A bee waiting on the dance area for making decision to choose a food source is called an onlooker and a bee going to the food source visited by itself previously is named an employed bee. A bee carrying out random search is called a scout. In the ABC algorithm, first half of the colony consists of employed artificial bees and the second half constitutes the onlookers. For every food source, there is only one employed bee. In other words, the number of employed bees is equal to the number of food sources around the hive. The employed bee whose food source is exhausted by the employed and onlooker bees becomes a scout. There are four phases[8] in ABC algorithm initialization phase, employed bees phase, onlooker bees' phase and scout bees phase. In initialization phase, from the search space the individuals are randomly selected. Mutation phase is added after the employed bee phase. The local search is done by employed bee phase. The local best position can be changed through mutation, and the algorithm may not be trapped into local optima. By sharing the information individuals can make use of others' advantage. For solving the job scheduling problem with the criterion to decrease the maximum completion time, crossover operator after the employed bee phase and mutation operator after onlooker bee phase of ABC algorithm are added.

C. Cuckoo Search Algorithm

Cuckoo Search Algorithm (CSA) [9] is based on the obligate brood parasitic behavior of some cuckoo species in combination with the Levy flight behavior of some birds and fruit flies.CSA is a new meta-heuristic approach that models the natural behavior of cuckoos. To describe the new CSA simplicity, the algorithm's idealized rules are summed up follows [9]:

• Each cuckoo lays one egg at a time, and dumps it in a randomly chosen nest. The best nest with high quality eggs (solutions) will be carried out over to the next generations.
• The number of available host nests is fixed, say n, and the host can discover an alien egg by a probability Pa [0, 1].
• The host bird can either throw the egg away or abandon the nest in order to build a completely new nest in a new location.

D. Particle Swarm Optimization Algorithm

Particle Swarm Optimization (PSO) [10] is a population based search algorithm inspired by the social behaviour of bird flocking and fish schooling originally designed and introduced by Kennedy and Eberhart [9] in 1995.A PSO algorithm contains a swarm of particles in which each particle includes a potential solution. Here a swarm is similar to a population while a particle is similar to an individual. The particles fly through a multidimensional search space in which the position of each particle is adjusted according to its own experience and the experience of its neighbours. PSO system combines local search methods (through self experience) with global search methods (through neighbouring experience), attempting to balance exploration and exploitation [11].Particle Swarm Optimization schedules applications to cloud resources that take into both computation cost and data transmission costs. The average computation cost is calculated for each and every task on all the resources. This can be calculated by executing the tasks in an application. The mapping of all tasks in the workflow is done initially. The dependencies between the tasks are validated and the algorithm assigns the "ready" tasks as per the mapping given by PSO. The ready list is updated when the task is completed. When communication cost changes, the PSO mapping has to be recomputed [12]. Depending on the recomputed PSO mapping, the ready tasks are assigned to compute resources.PSO optimizes the cost of task resource mapping based on the solution obtained.PSO finds global minima very quickly. PSO can attain good distribution of workload onto resources.

IV. CONCLUSION

Bio inspired algorithms are sure to leave its impact on the world as a new revolution in computer science. The scope of this area is so vast that it can open a new era in next generation computing, modelling and algorithm engineering. This paper provides an overview of a range of BIAs including ant colony optimization algorithm, artificial bee colony algorithm, cuckoo search and particle swarm optimization algorithm, the most powerful algorithms for optimization. Since the scheduling is NP-complete problem we get only a near optimal solution to this problem. There still remains significantly challenging tasks for the research community to address for the realization of many existing and most of the emerging areas in technology.

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