Survey on Machine Learning based scheduling in Cloud Computing

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ABSTRACT
In the modern era, cloud computing gains a lot of attention due to its various features such as it is simple to use, minimum cost, and mostly low power consumption. Many algorithms and techniques have been proposed for scheduling of virtual machines to provide dynamic load balancing, dynamic scalability and reallocation of resources. Intelligent algorithms are used for the optimization of results and minimizing the makespan scheduling while utilizing the resources efficiently based on dynamic environment. This paper reviews various intelligent scheduling algorithms such as Genetic Algorithm (GA), Simulated annealing (SA), Tabu Search (TS), Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Artificial Immune System (AIS), Bacterial Foraging Algorithm (BF), Fish Swarm Optimization Algorithm (FS), Cat Swarm Optimization Algorithm (CS), Firefly Algorithm (FF), Cuckoo Search Algorithm (CS), Artificial Bee Colony (ABC), Bat Algorithm (BA).

CCS Concepts
- **Computing methodologies~Machine learning algorithms**

Keywords
Machine learning, Scheduling Algorithm, Cloud Computing.

1. INTRODUCTION
CLOUD computing is a large scale distributed computing paradigm, driven by an increasing demand for various levels of pay-per-use computing resources. The basic building blocks of cloud computing model include providing infrastructure, platform and software as a service. These services are few likely our telephone service that is we have to pay only that much amount we use (pay per use). E.g. we only need a telephone in our home and needs not to set up whole exchange office personally. It's the job of telecom service providers to provide services from their exchange and one has to pay according to the services being used by him. Similarly, users submit their computing tasks from their devices to their cloud service providers which in turn, service their requests as per SLA (Service Level Agreement) with the customers.

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Cloud computing allows delivering computing resources by the means of internet. Cloud has emerged as a favorable technology to satisfy the computational needs of users. Various cloud services provide services [26], the cost of which is computed in terms of resource usage in Cloud. The three basic characteristics of Cloud are resource scalability, pay per usage and self service. Traditionally, the data of an organization is stored within the organization. When the data of more than one organization is stored outside with the help of third party outside organization and is, accessed over web. Then, such service is termed as web service over cloud. When the client requests the data, it can only access the data if he is authorized.

When resource requirements need to be met with fewer resources, the virtualization technique comes into play which is highly energy efficient technology. It allows cloud to be used by multiple users at a time and thus, supports on demand delivery.

Cloud provides infrastructure as a service, platform as a service and software as a service which can be accessed by the user on pay per use model. In traditional system, whenever user needs some software or platform, he needs to buy it. The temporary nature of the user needs leads to wastage of resources and money but cloud provides a solution to this problem by providing the resources on demand. This dynamic nature of requests by users leads to the problem of dynamic scheduling of requests in Cloud Infrastructure which is to handled by the cloud service providers with well defined strategy. Various scheduling algorithms have been used in scheduling jobs to attain the overall optimization of resources in Cloud Environment while providing high performance application interface to the user. to the In this paper, analysis of various intelligent techniques.

2. SCHEDULING ALGORITHM
A major concern of process scheduling in cloud is minimum outlay of time and energy. The average turnaround time and average cost of overall task scheduling should be minimized and to optimize task scheduling, optimization techniques have been used [1]. Scheduling algorithms have been categorized into two type's viz. traditional or classical and intelligent optimization scheduling algorithm. For load balancing, less execution time, response time and in many more parameters traditional scheduling algorithms like FCFS, shortest job first, round-robin and priority etc, are not recommendable over various scenarios. Due to inefficiency of classical optimization algorithms for solving larger problem spaces, a growing trend to meta-heuristic and intelligent optimization algorithms has been emerged which deals with the global optimization of a function. This paper presents a review of

various intelligent scheduling algorithms such as Genetic Algorithm, Simulated annealing, Tabu Search, Ant Colony Optimization, Particle Swarm Optimization, Artificial Immune System, Bacterial Foraging Algorithm, Fish Swarm Optimization Algorithm, Cat Swarm Optimization Algorithm, Firefly Algorithm, Cuckoo Search Algorithm, Artificial Bee Colony and Bat Algorithm

3. LITERATURE SURVEY

As scalability, heterogeneity, and complexity have gained importance, various nature-based [26] computing techniques are used to handle increased sophistication and proficiency. Bio-inspired computing is a fast-growing novel paradigm in communication and networking. Many researchers have been working toward using the role of biological systems and some of the various intelligent algorithms are discussed as:-

3.1 Genetic algorithm

Genetic Algorithm [2],[4] is a searching technique which works randomly based on Darwin theory. It uses current and historical data to analyze the future and this technique is used in VM scheduling. GA is based on the biological concept of generating the population. GA is considered a rapidly growing area of Artificial intelligence. According to Darwin's theory, term "Survival of the fittest" is used as the method of scheduling in which the tasks are assigned to resources according to the value of fitness function for each parameter of the task scheduling process. With the use of evaluation technique, this approach is highly scalable and consumes less energy than first fit decreasing and best fit decreasing. It usually gives the best load balancing results and avoids the migration of virtual machines making it more energy efficient. It considers the task completion time and energy consumed as dual objectives to be fulfilled. This has parallelism imposed internally in it and has the best optimizing ability. It will automatically search itself and itself decides the direction of searching. The increase of virtual machine has no impact on the response time conveying that the system has relatively high performance.

3.2 Simulated Annealing

Simulated annealing is inspired from annealing in solids where annealing in solids such as metal or glass means to heat and allow it to cool slowly, in order to remove internal stresses and toughen it.[4] It is a heuristic approach that has been implemented to obtain optimized solutions of various discrete problems. The origin of the algorithm is in statistical mechanism and the fundamental idea is that the costliest item in the bin is swapped with a random item that has the lowest cost. In this approach, random requests are allocated into a bin until a single parameter in the current bin is completely filled. It is based on two constrains, namely soft constraint which allows a solution to be replaced with better solution and in hard constrain, the capacity of the resource should never exceed the size of the bin. The iterative swapping is done until the solution reached a stable state. This method is highly flexible local search method and can successfully be applied to the majority of real life problems. SA algorithm [28] requires relatively a long time to find a global optimum, it has been demonstrated that the SA algorithm can converge to a global optimum by carefully specifying the cooling rate of the temperature. This algorithm starts by generating an initial solution and by initializing the temperature parameter which is purely an assumption [1] which is the major drawback. This algorithm usually stuck with local maxima, unwanted allocations are entrained and the algorithm also depends on the request availability and bin capacity. This approach works well with high temperatures.

3.3 Tabu Search

Tabu search is a "high level" meta-heuristic, [6]greedy approach for solving optimization problems based on the notion of move. The tabu search algorithm is a global optimization algorithm aiming to simulate human intelligence and has a better ability in local optimization. It is designed to guide other methods to escape the trap of local optimality, and has been applied to solve resource allocation and other optimization problems The overall approach is to avoid entrenchment in cycles by forbidding or penalizing moves which take the solution, in the next iteration, to points in the solution space previously visited. In Tabu search based heuristic, we use the solution obtained by Best-Fit heuristic as the initial solution, and adopt random move to find neighbors. The termination condition in the heuristic here is the moving times we required. In general we require the moving times should be twice than the number of the candidates in the solution pool, to increase the probabilities of visiting each candidate solutions through random move. Tabu search uses recency (short term memory) and frequency (long term memory) in order to search a solution space efficient by prohibiting the search from remaining in regions found to be locally optimal and forcing the exploration of other regions not yet encountered. It may encounter the optimal solution for a problem in shorter time that the other traditional methods.

3.4 Ant colony optimization

ACO is a meta-heuristic, population based, [8] stochastic and bio-inspired algorithm that mimics the behavior of ants designed to solve combinatorial problems. Ants use chemical substances called pheromones to implicitly communicate with other ants. When an ant explores and finds some target such as food, it secretes a pheromone along the route back to the colony. By doing so, other ants will follow the pheromone to travel down the trail and will also secrete a pheromone if they find the food. However, as time goes by, the pheromone gradually evaporates. Based on the ACO algorithm, the optimization problem can be transformed into the problem of finding the best path on a weighted graph.[9] The ants incrementally build solutions by moving on the graph. ACO can be used for scheduling generally focuses on reducing the number of physical machines. It achieve better global optimal solutions, have strong robustness achieve better global optimal solutions, have strong robustness and a a parallel algorithm. It has the disadvantage of overhead and falling for local optima.

3.5 Particle swarm optimization

Particle swarm optimization [10] is a highly advanced heuristic bionic intelligent optimization algorithm that mimics the behavior of animal swarm based on swarm intelligence. It is an adaptive searching algorithm based on group PSO algorithm can remember personal best information and global best information through collaboration between individuals. Initialize a group of random particles in a space, the particle position represents possible solution, each particle advances to a certain speed, particle swarm gradually approaches to the optimal location after repeated advances which are also called iteration, thus the optimal solution will be got. In each iteration,[4] the particles update themselves according to two extreme values: one is the optimal solution

finding by a single particle, namely the individual extremum; the other is the optimal solution finding by whole particle swarm, that is, namely the global extremum. Each particle in the population represents a possible solution of the problem to be optimized. Its objective is to solve the problem by modeling and predicting social behavior of insects. Instead of using random approach, it serves greater number of virtual machines. It provides the best load balance and reduces the throughput and response time. PSO algorithm is easy to trap into a local optimum. The computational time of the PSO algorithm is shorter than that of other existing metaheuristics, the precision of its final solution to the large-sized complex optimization problems is relatively poor [28]. The PSO algorithm is not robust to solve problems with different constraints The merits of parallel distribution, scalability, easy to realize, strong Robustness, with high flexibility in dynamic environments, PSO solves many combinational optimization problems successfully.

3.6 Artificial Immune System

The AIS is also a general meta-heuristic algorithm based on principles of the immune system, a [7] computational intelligence approach, called artificial immune system (AIS), has been developed. Artificial immune systems (AIS) constitute a family of bio inspired algorithms based on the models known from the studies of biological immune systems and immunology . Informally, biological immune systems protect the body from dangerous substances presented in the form of pathogens. They combine the ability to protect from both, general pathogens and specific attackers (e.g. different types of viruses, bacteria and so on) that cannot be be eliminated by the static (innate) part of the immune system . Artificial immune system algorithm includes the negative selection, clonal selection, and immune networks. The clonal selection is based on the selection theory describing the basic response of the immune system to an antigen. Negative selection is in the biological immune systems used to ensure that newly created lymphocytes will be able to adapt to new types of threats and remain tolerant to body cells at the same time. Immune network contributes to the stable memory structure of the immune system that is able to retain the information about the antigens even without their presence. It has been successfully applied to many fields such as clustering, classification, pattern recognition, computer defense, and optimization. AIS has the advantage of finding optimal makespan values of different size problems.

3.7 Bacterial foraging algorithm

Bacterial foraging optimization algorithm is a global optimization algorithm based on the population [5]search and efficient for global search method for the distributed computing. Bacterial foraging algorithm is a nature inspired optimization techniques that mimicking the foraging behavior of E. coli bacteria satisfies. It is a multi-criteria optimization problem. It gives optimized solutions to the multi-objective problem where simultaneous multi-criteria are needed to address simultaneously. This method is used for locating, handling, and ingesting the food. During foraging, a bacterium can exhibit two different actions: tumbling or swimming. The tumble action modifies the orientation of the bacterium[16]. During swimming means the chemo taxis step, the bacterium will move in its current direction. It is based on the nature where the selection process tries to preserve those animals that have ability to forage successfully and tries to exclude those animals with poor forage. Since the former have the more ability to succeed in reproduction process. It has the advantage to maximize the resource utilization and min the resource usage cost. It minimizes flowtime, makespan which are the important scheduling criteria in parallel and distributed computing. [28]

3.8 Fish swarm optimization algorithm

The artificial fish swarm algorithm (AFSA)[11] is a population-based meta-heuristic intelligent optimization algorithm inspired from fish swarm behaviors to solve combinatorial problems. AFSA is a random parallel search algorithm belongs to the family of swarm intelligence. This algorithm adapts the behavior of a group of fish swarm intelligence where the group globally searches for the food to reach the areas with a higher concentration. It then combines this intelligence with one of the methods to get the optimal solution of combinatorial optimization problems. [13]In an AFSA system, each artificial fish (AF) adjusts its behavior according to its current state and its environmental state, making use of the best position encountered by itself and its neighbors. It is highly flexible and more fault tolerant as it can be used for scheduling in cloud. It is expected to give the best results. It is insensitive to initial values, and possesses good performance such as fast convergence and robustness. It has gained an increasing study and wide applications such as multi-objective optimization and clustering problem.

3.9 Cat swarm optimization

An intelligent heuristic scheduling algorithm based on social behavior of cats, belongs to the family of swarm intelligence is cat swarm optimization.[15] It is based on the seeking and tracking behavior of cats. In seek mode, cats sense for the next best move while sitting in a place (without movement) while in tracking mode the cats chase the target by moving to the next best possible position with a velocity. The cat swarm optimization adapts this behavior of cats with the aim to solve multi objective workflow scheduling. The CSO maps the tasks and virtual machines by taking execution time, data amount and energy consumption as input and then searches for the best task resource mapping with fairness and offers the best fitness value. The solution obtained optimizes the overall energy consumption. It also provides an optimal task to resource scheduling that minimize the cost of scheduling. It is an improvement over PSO by reducing the number of iterations.

3.10 Firefly algorithm

Firefly algorithm (FA) is an intelligent meta-heuristic population based algorithm, inspired by the flashing behavior of fireflies. The firefly method is to dynamically create an optimal schedule based on swarm intelligence, investigating the travel behavior of fireflies which go looking for the closest possible maximum alternative. The blinking light in the fireflies is their attribute of attractiveness mainly used to attract mates and to defend themselves from other predators. In FA, fireflies are considered as simple agents that move and interact through the search space and record the best solution that they have visited. Therefore, FA can be employed to generate alternative design options in order to effectively support intelligent task scheduling on cloud computing to dynamically map the received jobs to the available resources in order to finish job's execution within minimum makespan time and evenly distribute the load. It can be used to solve multi-objective problems.[17],[18],[19]

3.11 Cuckoo search algorithm

Cuckoo search algorithm is a meta-heuristic algorithm that models natural behavior of cuckoo species. Cuckoos are the beautiful birds but their aggressive reproduction strategy is more interesting

to us. The cuckoos reproduce by the following rules where one egg is laid at a time and dumps it in a nest which is chosen randomly and in next step the nest which has the better quality eggs will be carried further for the next generation. It is assumed that there are fixed number of host nests. This strategy can be used for scheduling in cloud where the eggs represent the solution and algorithm works by replacing weaker solutions with the better solutions. This algorithm gives the optimal solution and effectively balances the local and global search with the help of switching parameter. The results obtained are better than particle swarm optimization.[17],[20],[21]

3.12 Artificial bee colony

Artificial bee colony algorithm is a population-based optimization meta-heuristic algorithm based on intelligent behavior of bees, which has two common types; foraging behavior and reproduction (mating) behavior. The ABC algorithm is based on the skillful foraging behavior of honey bee swarm. A typical hive may include 5,000 to 20,000 individual bees. Honey bees assume to have different functions within their colony through time. Active foraging bees go to a food source, check neighbor sources, collect food and return back to the hive. Scout bees examine the area surrounding the hive searching for plentiful new food sources. At any time some of the foraging bees become inactive. This strategy can be applied in the field of task scheduling is the foraging behavior. Mapping of bees foraging behavior to the task scheduling problem, can commonly be defined in a way that the employed bees are associated with allocating tasks on a resource and share their information about food sources. It minimize the completion time the search through solution space and diversifying the search. These characteristics make the artificial bee colony technique efficient to be applied in cloud task scheduling domain.[21],[12]

4. CONCLUSIONS & FUTURE WORK

Traditional approaches of task scheduling suffer from disadvantages like overpricing and slow processing for bulk of tasks. These scheduling algorithms are mostly based on cost reduction factor, deadline factor and even on priority based scheduling and they suffer from long waiting priority queues. The intelligent scheduling algorithm provides a fair solution to all of these challenges and provides a highly optimized, dynamic and more reliable scheduling scheme than the traditional. This paper overviews whe intelligent scheduling algorithm with meta-heuristic, swarm based approach. GA, SA and TS have less execution time. ACO reduces the number of physical machines required while PSO, CS give fair distribution. AI, FS, BF, ABC works well with less makespan. CS provides optimal resource utilization. FF, CS, BF increases convergence speed. CS, PSO has relatively less cost.

TABLE 1: Machine Learning Algorithms for Scheduling in Cloud

#	Algorithm	Parameters	Major Features & Disadvantages
1	Genetic Algorithm based on Darwin theory [2],[4]	Execution time, Resource utilization, No. of VM, makespan	• Self managing scheme • Global Search solution • Delivery of accurate results • Better resource utilization • Independent of no. of VM • Min. makespan and flowtime
2	Simulated annealing based on Annealing in solids [4]	Execution time Temperature Request availability Bin capacity	• Depends on resource availability and bin capacity • Less Average execution time GA • Stuck with local maxima • Unwanted allocations
3	Tabu Search based on notion of movement[6]	Execution time	• Less execution time • Do not stuck in local optima • Explore new regions • Premature termination
4	Ant Colony Optimization (ACO)[9]	Randomization No. of VM	• Reducing the number of physical machines • Global optimal solutions • Robustness • Falling for local optima
5	Particle Swarm Optimization [24]	Randomization Convergence Cost, Makespan Distribution	• Quick Converge local optima • Fair distribution • Minimize makespan • Lacking of reliability
6	Artificial Immune System [7]	Makespan	• Optimal makespan
7	Bacterial Foraging Algorithm [5] [16]	Makespan flowtime	• Reduced makespan • Minimim flowtime
8	Fish Swarm Optimization Algorithm [11],[13]	Makespan	• High efficiency • Less makespan
9	Cat Swarm Optimization Algorithm [15]	Cost Resource utilization No. of iterations	• Reduced no. of iterations • Optimal resource utilization • Fair distribution • less cost
10	Firefly Algorithm [17], [23], [18], [19]	Randomization parameter Light absorption Coefficient Population size	• Automatic subdivision of entire population. • Efficiently deal with multimodality. • Increased convergence speed.
11	Cuckoo Search Algorithm [17], [20],[21]	Population size Switching probability Step-size scaling factor Levi exponent	• Global convergence due to switching • Probability factor. • Use of levy flights result in efficient exploration of search space.
12	Artificial Bee Colony [21], [12]	Makespan Resource utilization	• Avg makespan is less than PSO and ACO • Better exploration of search space • Better Resource utilization

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