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Review on the Bat Algorithm and Various Metaheuristic Techniques for Efficient Parallel Scheduling

Kirandeep Kaur

CET Department, GNDU, Amritsar,

kirandeepkaurmahal04@gmail.com, +91-8427744766

Abstract— The various meta-heuristic techniques for cloud and grid environment are: Ant Colony Optimization (ACO), Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Tabu Search, Firefly Algorithm, BAT Algorithm and many more. So this paper represents the two types of meta-heuristic techniques, i.e. BAT algorithm and Genetic Algorithm. The different types of methods which comprise meta-heuristic algorithms range from simple local search approach to complex learning methods. It also shows the comparison of various techniques, i.e. one of the BAT intelligence (BI) and Genetic algorithm (GA) are used to figure out single objective multiprocessor scheduling problem utilizing objective functions as makespan, tardiness and power consumption. BI depicts significant improvement in terms of solution quality when compared with GA in terms of contradictory between makespan and energy furthermore among tardiness and energy.

Keywords— Bat Algorithm, Constant Absolute Target Direction (CATD) Technique, Metaheuristics, Dynamic Voltage Scaling, Energy-Aware Multiprocessor Scheduling, Energy Utilization, Normalized Weight Additive Utility Function (NWAUF)

1. INTRODUCTION

1.1. Cloud Computing

Over the last few years, cloud computing has come forth as one of the most promising resolutions for delivering IT oriented services to the users. Cloud computing has become popular for high performance distributed computing because it provides, "on-demand" having use of a shared pool of assets that would speedily provisioned over the web inside of a self-carrier, dynamically scalable and quantified way. Author use this environment to work out on various and large group of tasks[11]. Thus, scheduling problem up-here is going to be corresponding to multiple tasks to multi-machines. The purpose of scheduling is to outline the tasks to permit assets that optimize number objectives.

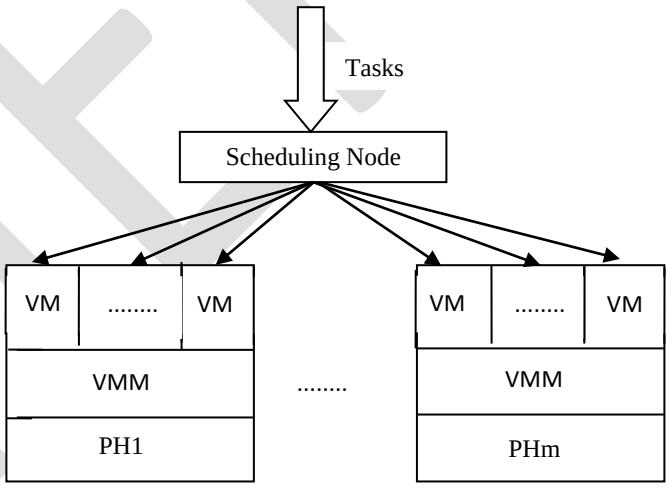

Figure 1. Framework of task scheduling on the cloud platform

1.2. Scheduling

Scheduling in cloud computing belongs to the problems are called N-P hard problems because of large resolution space and acquire long time to search out the solution[16]. Apply Meta-heuristics techniques to achieve sub-optimal algorithms in an effort to receive good solutions for such problems. Here, a novel heuristic termed as BAT intelligence (BI) is placed for fixing Multi-Objective Energy

Aware Multiprocessor Scheduling issues. BAT intelligence is based on prey hunting behavior. Multi-objective optimization approaches are used to solve parallel machine scheduling problems. The multiprocessor scheduling algorithm plays an important role to assigning parallel program tasks to the mainframes of multiprocessor devices, although conserving the preceding requirements and reduces the response time along with increase throughput of the system [1].

1.3. Dynamic Voltage Scaling (DVS)

Most recently, scheduling is carried out so as to reduce energy consumption at the same time meeting given hard timing constraints. To regulate and optimize system performance, these devices are engaged multiprocessor architecture[7].So Dynamic Voltage Scaling strategy is utilized in laptop or computer system to power consumption. It has been extensively recognized as a robust along with possible methods for concession power utilization for execution time. In Dynamic Voltage Scaling (DVS) diverse electric potentials (voltages) are directed to multiprocessors in a way every mainframe can differ its developing rate of motion while accomplishing a specific task that permit reducing power consumption and increasing system throughput [18]. Dynamic Voltage Scaling is also known as N-P hard and involves utilization of heuristic in less time to acquire good solution. The system objectives in multiprocessor scheduling problems are: maximum throughput, minimum tardiness and minimum power utilization

1.4. Normalized Weight Additive Utility Function (NWAUF)

The energy aware multiprocessor scheduling problems, therefore, normally multi-objective optimization problems satisfies multiple conflicting objectives[10]. A recognized well known procedure for solving multi-objective optimization problems are Normalized Weight Additive Utility Function (NWAUF) whereas collective targets are normalized and introduced to create a utility function. Normalized weight additive utility function has been utilized in a broad layout of multi-objective optimization.

1.5. BAT Intelligence

BAT intelligence formulation solves the problem of single objective and multi-objective optimization problems. BAT intelligence created by determining the behavior of bat of hunting the prey[13]. The bat is waiting for the prior conveyed signal to the comeback before transmitting resulting signs and extract data from the returning signs to generate its subsequent move. Bat engages Constant Angle Target Direction (CATD) method while chasing a prey and the bat sustains the same chasing angle to pursue prey because this is the best technique for seizing a prey or food moving at arbitrary directions. Therefore, bat captures numerous preys throughout the chasing process.

Bat intelligence is also formulated for resolving energy-aware multiprocessor scheduling problems.Energy-aware contains two challenges: job/task arrangements and current scaling[13]. These are the framework that integrates collectively to decrease energy consumption of real-time reliant tasks on a given number of variable voltage mainframes. In Bat intelligence, arrangement of task/job and voltage scaling executes simultaneously where BI to eliminate Energy-Aware Multiprocessor Scheduling problems[14]. BI utilizes to resolve number of multiprocessor scheduling problems as various quantities of jobs, tasks as well as processors, by combining two or three objectives to locate lists of efficient solutions for multiprocessor scheduling problems.

2. TECHNOLOGIES USED

2.1. Metaheuristic Techniques

Heuristic intends ‘to discover’ or ‘to detect by trial and errors’. Excellent solution from hard optimization problems can determine in a reasonable amount of time. But it is not necessary to get best or optimal solution. Meta intends ‘beyond’ or ‘higher stage’ and is usually superior to basic heuristic. It is outlined as an iterative generation approach leading a subordinate heuristic by merging intelligently unique concept for “exploring and exploiting” the search area, finding out methods are used to structure data in an effort to locate effectually near optimal solutions[17]. Techniques which constitute meta-heuristic algorithms range from simple local search procedures to complex learning processes. Meta-heuristic techniques are used to prove near optimal solutions within less time period for N-P hard problems. Various meta-heuristic techniques for cloud and grid environment are: Ant Colony Optimization (ACO), Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Tabu Search, Firefly Algorithm, BAT algorithm and many more.

A. BAT Algorithm

The standard BAT Algorithm was created by Xin-She-Yang in 2010. The main features in the bat are based on the echo sounding nature of microbats. They discover their way in the night by radiating the sound signal called sonar/echolocation and used that signal to detect the object or obstacles surrounding them. They emitted sonar signal very noisy, so that they can listen echo which bounce back from the obstacles in their way or from the prey. Such echolocation nature of microbats will also be developed into a technique that can be related with the objective features to be enhanced and it can be used to develop a new optimization algorithms.

After idealize, three major characteristics of microbats are used to develop the basic structure of BAT algorithms[17]:

1. Most of bats utilize echolocation to detect distance and they usually also "know" or guess the distinction between food or target and background obstacles in some means.
2. Bats travel randomly with v_i speed at x_i position with a fixed frequency f_i, changing wavelength λ as well as loudness $A_{0,}$ to seek for prey. They are able to instantly alter the wavelength (or frequency) of their released pulse rate and modifies the speed of pulse emission 'r' in the range of [0,1],rely upon the target proximity.
3. Despite, the sound intensity can fluctuate in many approaches. For simplicity, the sound intensity varies from large and positive A_0 to minimal steady value which denotes by A_{min}.

THE PSEUDO CODE OF THE BAT ALGORITHM:

The standard steps of proposed Bat Algorithm are as follows:

Step1. Evaluate the initial population of Bat have position z_i and velocity v_i.Determine pulse frequency $f_i$at z_i. Loudness A and pulse rate r_i are initialized.

Step2. By adjusting the frequency, new solutions are generated and updating velocities and positions/solutions.

Step3. If (random > r)

From the best solutions, select the solution and around the selected best solution generate a neighborhood solution.

Step4. Else

Fly random to create a new solution.

Step5. If (random <A && $f(z_i) < f(z_0)$)

whereas $f(\cdot)$= objective function.

Acknowledge the new solution, increase and diminish A.

Step6. Find the current best (z_0) by ranking the bats.

Step7. While (iteration< maximum number of emphases)

Post procedure outcomes and representation. The algorithm terminates with the best aggregate solution.

B. Constant Absolute Target Direction(CATD) Technique

Bat use the Constant Angle Target Direction approach while pursuit a prey and in which the bat holds the identical pursuit angle throughout capturing the prey. The bats determine the position of the quarry through conducting echolocation signs and capture the quarry in a continuous manner. Bat intelligence merges the concepts associated with CATD and echolocation to provide a collection of signs and select the most effective signal to transfer toward best results. This done by transmits search signals at each sequence and identify at each sequence and identify the location of prey by determining the coming back signs. Whenever a bat pursuit and utilizes a prey, it forwards to other prey within scrounging field. This intends that bat's hunting process will pursue multiple preys.

Bat generalized a set of solutions in each iteration and the best solution is to be chosen from selected solution. When common element is choosen, the ending status is assured to decide whether to proceed with the heuristic or not. At each iteration terminating conditions are checked and if it satisfies, then current cycle terminates and next cycle starts. When a new iteration starts, BI reinitialize captured procedure.

C. Dynamic Voltage Scaling (DVS) Technique

Dynamic Voltage Scaling is an approach to discovering the hardware characteristics associated with processors to reduce power consumption by lowering the supply of voltage and the performing frequency. It is a power management technique in computer architecture where voltage can increase or decrease according to the situation. In DVS, different voltages are provided to multi-processors as every processor may deviate its processing speed and while performing a particular task, that allow to modify the total energy utilization and system throughput for each processor.

The DVS techniques are used to produce dramatic power saving as supplying the high computing power in a general purpose system. Yet, for a significant category of functions in the entrenched real-time process, the varying operating frequency insures with their deadline ensure mechanism and DVS. To supply real-time guarantee, DVS ought to look at deadlines and a series of actual-time duties

requiring integration with specific time scheduler. DVS has been taken knowledge of the high variance in processing demands by varying the frequency and processor's operating voltage for the duration of run-time. DVS has the ability to deal compromise between energy and speed. Therefore, endeavor of the processor varies, there are ideal periods when utilization is performed and energy is consumed. DVS can be used to remove power wasting time by way of reducing the processor voltage and frequency although less workload time. So that processor will have relevant work, that leads to reduction in overall power utilization.

D. Normalized Weight Additive Utility Function (NWAUF)

Many approaches used to solve multiple objective optimization problems and one optimal solution does not exist. Also objectives are conflicting in nature. One of the most used techniques is the Normalized Weight Additive Utility Function (NWAUF). In NWAUF multi-objectives, normalized and utility function is formed by adding them. Due to its simplicity and effectiveness for efficient solution, NWAUF has become integrated into the range of multi-objective optimization applications.

RELATED WORK

Pablo Eliseo Reynoso Aguirre and María de Guadalupe Cota Ortiz et al.2015 [13]. This paper applies Bat Algorithm to scheduling and work allocation using a multiprocessor, in which the main objectives of the problem that intends to minimize are makespan and tardiness. In this type of problems usually employ a scheduler, which divides the amount of available time of all of the processors between all of the processes associated towards problem in order to be executed. Naturally, the scheduler only selects tasks that could be able to be executed and this has basically no dependence restriction incomplete which has to be needed for its execution. Rahli Mostefa, Latifa Dekhici et al. 2015[14]. Experiment proposes to solve a well known power Redundancy Optimization Problem (ROP) known as Power system design optimization applying bio-inspired metaheuristic Bat Algorithm (BA). Here aggregate them to Universal Moment generating Function (UMGF). The problem creates, on choosing the suitable elements from the system have minimum cost so to accomplish a reliability of the system. Observational results describe that the algorithms can search the best design and give superior results. Behnam Malakooti , Shaya Sheikh, Hyun Kim et al.2013 [5]. A different heuristic known as bat intelligence (BI) is initialized for determining energy-aware multiprocessor scheduling problems. Bat intelligence is generally a new search space development approach which designs on prey chasing behaviors of bats. As compared to GA, the BAT algorithm is more significant regarding solution quality. For solving bi-objective multiprocessor scheduling problems and Tri-objective multiprocessor scheduling problems are also introduced. A Normalized Weighted Additive Utility Function (NWAUF) is utilized to obtain desirable efficient solutions. Association, among makespan and energy, and even among tardiness and energy is conflicting shown by computational simulation. M. Mezmaza, N. Melab, Y. Kessaci, Y.C. Lee et al.2011 [12]. Difficulty of scheduling priority restricted parallel purposes on Heterogeneous Computing Systems (HCSs). These types of works considered methods to reduce the finishing time (makespan) after having much care about energy utilization. Author; determine an alternate aligned bi-objective hybrid genetic algorithm that considers, not merely makespan, but also utilization of energy. The new technique will be depend upon Dynamic Voltage Scaling (DVS) to lessen energy decay. Xiaohui Li, Lionel Amodeo and Hicham Chehade et al. 2010 [16].Multi-objective parallel machines scheduling problem is solved during this paper. It comprises in scheduling 'n' impartial tasks of 'm' identical parallel machines. The goal will probably be to improve two unique aims: the makespan and the entire tardiness. Non-Dominated Sorting Genetic Algorithm (NSGA-II) is projected to fix this issue. Ever the frameworks of a Genetic Algorithm are actually challenging, a formal logic administrator together with the NSGA-II (FLC-NSGA-II) consequently remains proposed. The experimental results exhibit the benefits and likewise the effectivity of FLC-NSGA-II. Lee Kee Goh, Bharadwaj Veeravalli et al. 2009 [9]. With this particular paper, 2 heuristic Energy-Aware Scheduling Algorithms: 1) Energy Gradient-based Multiprocessor Scheduling (EGMS) algorithm and 2) Energy Gradient-based Multiprocessor Scheduling with Intra-task Voltage scaling (EGMSIV) algorithm enhance EGMS. For arranging task priority charts in the fixed multiprocessor system having working factors capabilities with dynamic voltage scaling. The outcome display algorithms are able to get energy-efficient schedules utilizing less optimization time. A. Berrichi, F. Yalaoui et al.2009 [2]. A recent bi-objective method enables the administrator to locate compromise solutions between the event objectives and sustenance ones. The target would be to concurrently enhance two principles: the reduction of the makespan for the progress section and also the decreasing of the system in accessibility for taking care aspect. Two selections are taken simultaneously: finding the very fine work of 'n' jobs to 'm' machines to be able to scale down the makespan and determining when to make use the deterrent upkeep moves so as to minimize the approach unavailability. Two progressive genetic algorithms are in contrasting with finding an estimation of the Pareto-optimal front in the parallel computer case. Jiong Luo and Niraj K. Jha et al.2007 [7]. This article deals with the situation of variable-voltage arrangement of tasks with priority associations with heterogeneous allocated actual time enclosed systems. It executes power-profile and timing-detention consumed abate distribution to optimize energy minimization through voltage scaling. It could be built into the interior circle of approach degree synthesis device for conceive space analysis of actual-time assorted fixed methods, because it is very quick.

4. COMPARISON TABLE

Ref No	Authors	Year	Title	Technique	Hetero-geneity	Meta-heuristic	Convergence Speed
13	Pablo Eliseo		Multi-	BAT			

	Reynoo Aguirre, and Pedro Flores Perez	2015	Objective Optimization Using Bat Algorithm to Solve Multi-processor Scheduling andWorkload Allocation Problem.	Algorithm	Yes	Yes	Higher
14	Rahli M.,Guer-rache K.,	2015	BAT Algorithm to Series-Parallel Power System Design	BAT Algorithm	No	Yes	Average
5	Behnam Malakooti & Hyun Kim & Shaya Sheikh	2012	Multi-objective energy aware multiprocessor scheduling using bat intelligence	BAT Intelligenc e	Yes	No	Average
12	M. Mezmaz, N. Melab, and Y. Kessaci	2011	A parallel bi-objective hybrid meta-heuristic for energy- aware scheduling for cloud computing systems	parallel bi-objective hybrid genetic algorithm, Dynamic Voltage Scaling	Yes	Yes	Higher
16	Xiaohui Li, Lionel Amodeo, Farouk Yalaoui	2010	Multi-objective optimization approach to solve parallel machines scheduling problem	Non-dominated Sorting Genetic Algorithm (NSGA-II)	No	Yes	Higher
9	Lee Kee Goh, Bharadwaj Veeravalli	2009	Design of Fast and Efficient Energy-Aware Gradient-Based Scheduling Algorithms For Hetero-geneous Embedded Multiprocesso r Systems	Energy aware scheduling algorithms	Yes	No	Average

2	A. Berrichi · L. Amodeo.	2009	Bi-objective optimization algorithms for joint produ-ction and maintenance scheduling: application to the parallel machine problem	Genetic Algorithms	Yes	Yes	Higher
7	Jiong Luo and Niraj K. Jha	2007	Power-Efficient Scheduling for Heterogeneous Distributed Real-Time Embedded Systems	Energy Efficient scheduling	Yes	No	Poor

CONCLUSION

Meta-heuristic techniques are used to prove near optimal solutions within less time period for N-P hard problems. In this paper comparison of various meta-heuristic techniques has been carried out. As table shows that Bat algorithm converges very quickly at the early stage and the convergence rate slow down as well as Large scale problem is not cleared what the best values for most applications. So to overcome these issues in the near future we will propose a hybrid technique for parallel scheduling using BAT and TABU search.

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