A Novel Approach of Load Balancing in Cloud Computing using Computational Intelligence

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***Abstract*— Nature Inspired Meta-Heuristic algorithms are proved to be beneficial for solving real world combinatorial problems such as minimum spanning tree, knapsack problem, process planning problems, load balancing and many more. In this research work, existing meta-heuristic approaches are discussed. Due to astonishing feature of echolocation, bat algorithm has drawn major attention in recent years and is applicable in different applications such vehicle routing optimization, time-tabling in railway optimization problems, load balancing in cloud computing etc. Later, the biological behaviour of bats is explored and various areas of further research are discussed. Finally, the main objective of the research paper is to propose an algorithm for one of the most important application, which is load balancing in cloud computing environment.**

Keyword-Bat Algorithm, Cloud Computing, Load Balancing, Meta-Heuristic Approach, Tabu Search

I. INTRODUCTION

Combinatorial Optimization problems involve finding a finite set of objects among feasible solutions, which satisfy given conditions. Combinatorial Problems are not only limited to find the shortest path in vehicle routing problems, for planning, scheduling and time –tabling in railway optimization problems, Minimum Spanning tree, Knapsack problem, but are widely arise in different fields of engineering and other application domains. Finding the exact solution for these types of problems is difficult. To tackle with these types of problems, meta-heuristic approaches are used. Self-Organization is the principle mechanism of these meta-heuristic approaches. Positive Feedback, Negative Feedback, Randomness, Multiple interactions are the elements of meta-heuristic approaches. Nature inspired meta-heuristic approaches are broadly classified into evolutionary algorithms, physical algorithms, swarm intelligence, bio-inspired and other nature inspired algorithms [11].

Genetic Algorithm makes the use of crossover and mutation operations to obtain optimal results. Differential Evolution optimizes the problem solution by maintaining a set of agents (candidate solutions) and new agents are created using existed agents, with the help of mathematical concepts. Based on the fitness value, best agents are selected under given constraints. Genetic Programming (GP) is a machine learning technique which optimizes the given set of computer programs, based on the fitness value [1]. In GP, fitness value calculation depends on the ability of the computer program to execute the given task. PSO calculates and updates the fitness value of the candidate solutions in a search space to find the optimal solution. Based on behavior of cats, author in [4] has defined two sub-models of cat swarm optimization, namely, trace mode and seek mode. To solve unimodal and multi-modal problems, Runner-Root Algorithm is used, inspired from runners and roots of plants. Intelligent Water Drops obtains optimized result by mimicking the behavior of natural water drops. Ant Colony optimization makes the use of pheromone of ants to convey the information to other ants [6]. Based on the waggle dance of honey bees, artificial bee colony (ABC) optimization is proposed by Karaboga. The main concept of ABC is to communicate with other bees, using waggle dance. Based on the echolocation of bats, an optimization algorithm is proposed in 2010 [16]. To search and find most suitable location for the growth and reproduction of weeds, Invasive Weed Optimization algorithm is proposed. Firefly's flash signal is used to communicate with other fireflies in proposed algorithm of Xin She Yang. Breeding behavior of cuckoos of lying eggs in other bird's nest inspired the author of [17] to propose an optimization algorithm on the same phenomenon.

In Harmony Search, multiple musicians play note together to achieve global optima. Based on the collective movement and social behavior of fish, Artificial Fish Swarm Algorithm is proposed [12].

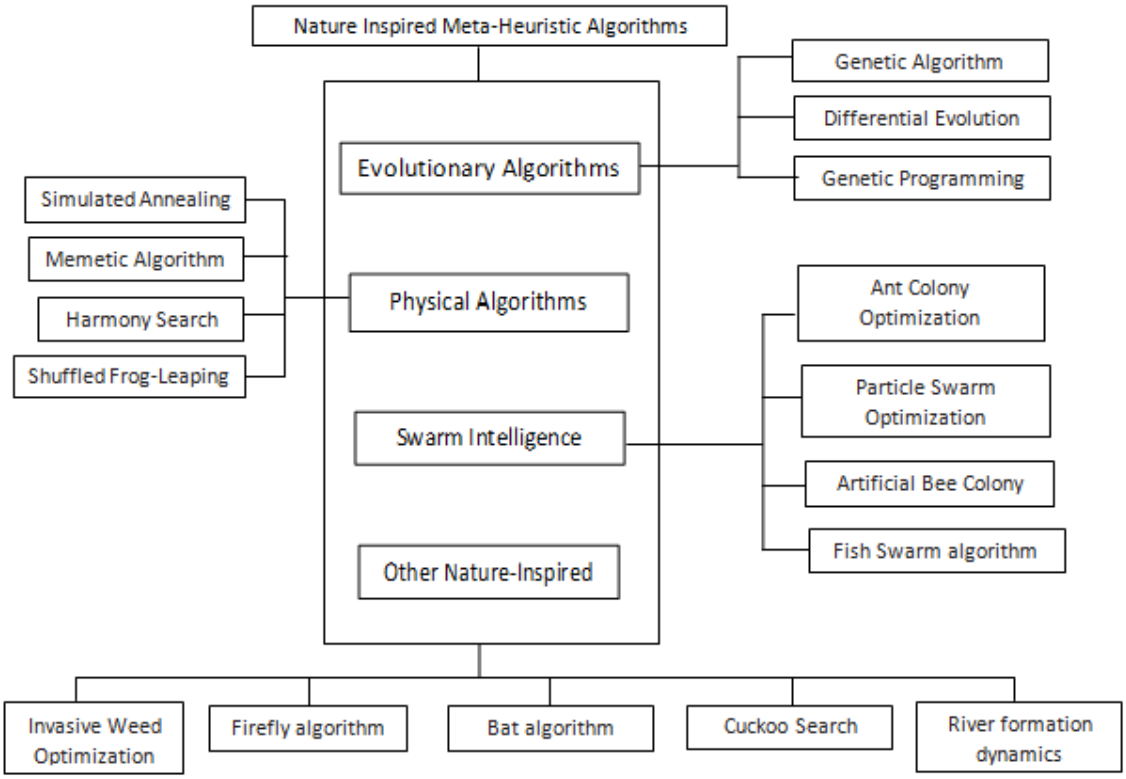

Figure 1: Categorization of Nature-Inspired Algorithms

Researchers are contributing in the field of swarm intelligence by improving the performance of these meta-heuristic approaches in one or the other way. But still, advantages and disadvantages of each algorithm exists. Major focus of Bat algorithm variants is on three areas: intensification and diversification process, initialization and updation of parameters. The aim of this research is to explore the biological behaviour of Bat algorithm to achieve more optimized results.

II. STANDARD BAT ALGORITHM

Echolocation behaviour of real bats has inspired Xin She Yang to propose a new meta-heuristic technique to solve different types of combinatorial problems in the year of 2010 [16]. The author has suggested that the parameters, i.e. frequency, position and velocity need to be updated, in order to obtain the optimal solution among various feasible solutions. As real bat approaches prey, the pulse rate emission should be reduced and loudness should be increased. Based upon these concepts, the author has proposed following algorithm to achieve optimization.

Algorithm 1: BAT Algorithm

Data: Initialize bat population position x_i,
velocity v_i , pulse rate r_i, loudness a_i
and frequency f_i.
Result: Optimized Solution
Begin
Set maximum number of iterations
and represent it using max.
while (curr_iter<max)
Generate new solutions by adjusting position,
Frequency and velocity
If (rand > r_i)
Select best solution among all solutions
Generate a local solution around the selected best solution.
End if
If ((rand < a_i) && (f(x_i) < f(x^*))
Accept new solutions and
Increase r_i and reduce a_i.
End if
Rank the bats and find the current best solution, x_i.
End while
Post-process the results.
End

Figure 2: Standard BAT Algorithm

Bat algorithm is capable of solving different types of complex problems very quickly by changing its state from exploration to exploitation. But, due to this quick transformation from exploration to exploitation, bat algorithm easily traps in local optima. Moreover, major focus of Bat algorithm variants is on three areas: intensification (exploration) and diversification (exploitation) process, initialization and updation of parameters. In the next section, biological behaviour of real bats is explored to achieve more optimized results.

III. BIOLOGICAL BEHAVIOUR OF BATS

Bat adjusts the frequency, position and velocity according to the movement of prey. Updating factor of these parameters differ from search phase to approach phase, from approach phase to tracking phase and from tracking phase to terminal phase. Narrowband and Broadband are the two types of signals produced by bat during echolocation. These signals are further categorized into Frequency Modulated (FM) Signals and Constant Frequency (CF) Signals. Which type of signal will be produced by bats, depends on what kind of information, bat wants to acquire about the environment. FM signals are best for determining target distance. CF signals are better for long range detection and for detecting target motion [10]. To prevent pulse-echo overlap, bats shorten the duration of FM signal produced. Pulse emission by one bat, in the presence of another, leads to interference of sound waves and echo produced by both bats. To avoid this interference, bats cease vocalization and enter silent mode [2]. Shifting from vocalization mode to silent mode depends on the relative positions of bats. Without actively echolocating, silent bat can acquire the information about the location of other bats and objects and can also avoid collisions, by listening passively. In [8], author has suggested how bats avoid overlapping of sound produced and echo received during approach, target and terminal phase of prey capturing. Bat search space depends upon the search cone angle, formed from the mouth of bat. Larger the angle, larger the search space and hence increases exploration. Bats are not only able to identify different targets with the help of echolocation, but also identify different parts of the complex object which are located at different ranges [15]. Bats are able to calculate jitter in echo delays before deciding which prey to capture. Three different flight behaviors are described in [6] of bats. Relative position of bat with respect to conspecifics, along with details of angle between two bats is mentioned by the author. In [10], author has described detection process as identification of a signal, even in the presence of background noise. Source level, Target Strength, Transmission Losses, Noise Level, Directional Index and Directional Thresholds are the major elements for separating the

signal from noise. Based on the differences in echo spectra, shape and type of target can be discriminated [8]. Moreover, author has suggested that information about the object size, shape and surface properties are encoded in temporal and spectral elements of echo structure.

Echolocation not only helps bat to find the location of the prey, but also helps the bat to decode other information, including distance between bat and prey, angular direction and target size. Inclusion of these features of real bat, will lead to the development of new variants of bat algorithm. Moreover, there is effect of sound attenuation on bat loudness, pulse rate emission and echo produced. Based on these newly explored characteristics of real bats, some interesting variants of bat algorithm can be proposed, which will be applicable in different application areas, like vehicular ad hoc network, cloud computing, training of feed forward neural network, solving ergonomic work place problems, classification of gene expression data, job scheduling in cloud computing environment and many more engineering problems. In this research work, an algorithm is proposed to balance the load of virtual machines.

IV. Load Balancing in Cloud Computing

Cloud Computing offers the flexibility to pay as per-use to the users, along with the advantage of cost and availability of services. Load balancing techniques allow cloud computing paradigm to scale up to the increasing demands of users by efficiently allocating the tasks among the available virtual machines. In previous years, different techniques are proposed for balancing the load in cloud computing environment. In [7], author has proposed fuzzy based load balancing technique. The author of [9] reviewed various meta-heuristic approaches that have been used in past for job scheduling in cloud computing. Ant Colony based load optimization technique has been proposed by the author in [5]. Artificial Bee Colony based load balancing technique has been proposed by J. S. Pan et al in [13]. In [14], author has suggested the use of bat algorithm for job scheduling in cloud computing and also mentioned that more optimized results can be obtained in load balancing, with the use of bat algorithm. So, in this research work, the main focus is on the load balancing in cloud computing.

V. Proposed Algorithm For Load Balancing in Cloud Computing

In the Cloud Computing, one of the objectives is to allocate the tasks to appropriate virtual machines, for execution. Before allocating the tasks to the virtual machines, resource requirement for task execution and resource availability of the virtual machines is considered, to select the best virtual machine for task execution. When any virtual machine is under-loaded or over-loaded, tasks need to be migrated from one virtual machine to another. To allocate the tasks to appropriate virtual machine, Bat algorithm is used, along with the concept of Tabu Search. The use of Tabu Search will provide the ability to the bats to memorize the visited solutions and avoid visiting it again and also avoid the bat to visit the neighbors of current best solution. The neighbors of visited solution are placed in “Non-Allowed” set. The solutions which are placed in “Non-Allowed” set will be used for migration of jobs during over-load and under-load situations of virtual machines. In this proposed algorithm, tasks will be considered as artificial bats and virtual machines will be treated as prey. The proposed algorithm offers better exploration and diversity of search space, by avoiding visiting the same solution again.

STEP 1: Initialize the parameter of bat algorithm, i.e. position, loudness and velocity.

STEP 2: Define the set of Virtual Machines VM_i which consists of VM_1, VM_2, ……, VM_n

STEP 3: Define the set of Task T_i which comprises $\{T_1, T_2, \ldots\ldots T_n\}$ tasks.

STEP 4: Resources required for the execution of the tasks are represented as RR_i.

STEP 5: Set of resources available in VM_i are represented as RA_i.

STEP 6: Tend the bats to select the optimal virtual machine which fulfil the task requirements, using bat algorithm.

STEP 7: With the help of Tabu Search and to avoid trapping into local minima, the neighbours of selected VM are blocked for current iteration. These set of VM_i are said to be Non-Allowed set and non-neighbours are considered as a set of allowed VM.

STEP 8: Repeat the process to select optimal VM for each task execution.

Algorithm 2: Load Balancing Algorithm

Data: Set VM_i as group of Virtual Machines.

Set T_i as group of Tasks to be executed by VM_i.

RA_i and RR_i represent resources availability and resource requirements of VM_i and T_i respectively.

Result: Optimal Selection of VM

Begin

Apply bat algorithm to select appropriate Virtual Machine VM_i for the execution of Task T_i.

Use Tabu Search to avoid the use of neighbors of selected VM_i.

In case of under-load and overload of VM_i, set Non-Allowed Set = $\{VM_{i-1}, VM_{i+1}\}$ and remaining virtual machines are said to be in allowed set.

End

Figure 3: Load Balancing Algorithm

VI. Conclusion and Future Work

Bat algorithm has drawn the attention of many researchers in recent years, because of its applicability in solving many real world problems such as training of feed forward neural networks, solving ergonomic work place problems, classification of gene expression data, job scheduling in cloud computing environment and many more engineering problems. Echolocation allows bat to locate and identify the object (prey) even in complete darkness and captures prey in no time. Echolocation not only helps bat to find the location of the prey, but also helps the bat to decode other information, including distance between bat and prey, angular direction and target size. Inclusion of these features of real bat, will lead to the development of new variants of bat algorithm. Moreover, there is effect of sound attenuation on bat loudness, pulse rate emission and echo produced. In future, various factors will be introduced to standard BAT algorithm and effect of attenuation will be evaluated and validated using MATLAB tool.

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