A Study on Load Balancing in Cloud Computing Environment Using Evolutionary and Swarm Based Algorithms

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***Abstract*— Literature meaning of cloud computing is distributed computing, storing, sharing and accessing data over the Internet. It provides a pool of shared resources to the users available on the basis of pay as you go service, means users pay only for those services which are used by him according to their access times. The data processing and storage amount is increasing quickly day by day in cloud environment. This leads to an uneven distribution of overall work on cloud resources. So a proper balance of overall load over the available resources is a major issue in cloud computing paradigm. Load balancing ensures that no single node will be overloaded and used to distribute workload among multiple nodes. It helps to improve system performance and proper utilization of resources. It also minimizes the time and cost involved in such big computing models. Load balancing and better resource utilization is provided by many existing algorithms. To overcome load balancing problem this paper provides a summary of evolutionary and swarm based algorithms which will help to overcome such problem in different environment of cloud.**

Keywords*— *Cloud computing, load balancing, evolutionary algorithms, swarm based algorithms, quality of services (QoS), distributed computing, genetic algorithm (GA), particle swarm optimization (PSO), ant colony optimization (ACO), artificial bee colony algorithm (ABC)

I. INTRODUCTION

Cloud computing is a newly emerging technique which provides online computing resources and storage. Users can access these resources at any time through internet which can be located at any point on earth. There are many existing issues in cloud computing. Load balancing in cloud computing is one of them [1, 2].

Cloud computing has became very popular in the last few years [1, 3]. Size of computation and demand for higher computation is growing very rapidly which is causing an uneven and heavy workload on cloud resources. Load balancing helps to distribute all loads among all the nodes [4]. This guarantees that each and every processing unit is dispersed well. Basically this technique helps in prevention of bottlenecks of the overall system which occurs due to load disparity [5]. One important issue associated with this field is dynamic load balancing [6]. Load balancing algorithms were investigated heavily in various environments; however, with cloud environments, some additional challenges are present and must be addressed, it gives a high satisfaction to the users. Load balancing is a relatively new technique that provides high resource utilization and better response time. As part of its services, it generally provides a flexible and easy way to keep and retrieve data and files [7, 8], especially for making large data sets and files available for the spreading number of users around the world [2, 3]. Handling such large data sets require several techniques to optimize and streamline operations and provide satisfactory levels of performance for the users [4, 5]. Therefore, it is basically important to research some areas in the cloud to improve the storage utilization and the download performance for the users. In cloud computing the main concerns involve efficiently assigning tasks to the cloud nodes such that the effort and request processing is done as efficiently as possible [1], while being able to tolerate the various affecting constraints such as heterogeneity and high communication delays.

II. RELATED WORK

Distribution of workload in a balanced manner is a main challenge in cloud computing system. It distributes workload among multiple nodes, hence resources are properly utilized. This is an optimization problem and a good load balancer should be involved for this strategy to the types of tasks and dynamic environment [9]. Many optimization approaches are given for the load scheduling problem and simple applications.

Kousik Dasgupta et al. (2013) [9] have proposed a Genetic Algorithm (GA) over load balancing strategy. This optimization technique balances the load of the cloud environment, minimizing makespan of task. Cloud analyst simulator is used to simulate the proposed load balancing strategy. Some existing approaches like First Come First Serve (FCFS), Round Robin (RR) and Stochastic Hill Climbing (SHC) are used for simulation. GA utilizes all the dedicated resources associated with it. This proposed technique is better than few existing techniques; it also supports the QoS requirement.

A. Paulin Florence et al. (2014) [10] have developed a firefly algorithm for load balancing in cloud computing. By using this algorithm load will be balanced properly. The proposed algorithm always gives the optimized result. The

978-1-4799-4190-2/14/$31.00 ©2014 IEEE

performance analysis of the proposed approach produced expected results so it is efficient for load balancing. In the proposed approach CPU rate is efficiently utilized than the existing approach and load is properly balanced.

Andrew J. Page et al. (2005) [11] Proposed a task scheduling problem which dynamically schedule processors in a distributed environment. The scheduler operates in changing environment and is adaptable to variable system resources. It basically operates on batch and use genetic algorithm for minimizing the processing time.

Akhil Goyal Bharti et al. (2014) [12] explains a business oriented approach. There are a number of soft computing techniques available to optimize the load. In his paper he compared various soft computing techniques to reduce that problem.

Zhanghui Liu et al. (2012) [13] proposed a PSO-based techniques to balance the load in VMs (virtual machines) of Cloud Computing Environment. Here the author proposed a new task scheduling model to optimize the time for task execution and utilization of resource.

Pooja Samal et al (2013) [14] proposed R-R (round-robin) algorithm for balancing the load of cloud service provider. Here the author has analyzed various policies utilized with different algorithm for load balancing using a tool (cloud analyst) for improving the server's performance.

Zehua Zhang et al. (2010) [15] has introduced a load balancing methodology which is based on ACO and multifaceted based network theory in open cloud computing where the author proposes a load balancing mechanism on the basis of ant colony and network theory in open cloud. This paper basically deals with the realization of load balancing in distributed system. Here GA is developed over scheduling algorithm to obtain better efficiency in unknown conditions, better schedules and low makespan.

Kun Li et al. (2011) [16] have given a survey on cloud task scheduling based on Load Balancing considering Ant Colony Optimization. Authors propose a policy cloud task scheduling based on Load Balancing Ant Colony Optimization (LBACO) algorithm. The main work done here is to balance the entire system and try to minimize the span of a given task set. Here PSO is used over previously proposed model to optimize the load balancing. Here the proposed approach is overviewed.

Klaithem Al Nuaimi et al. (2012) [17] elucidates in his survey report about the challenges of load balancing. The author suggested providing efficient mechanisms and algorithms for assigning the client's requests to available cloud nodes. These approaches aim to give suitable and well-organized services to the user and improve the cloud performance. Here a new task scheduling model is proposed to overcome this load balance problem. The new model reduces the execution time, running time and resource utilization.

Dhinesh Babu L.D et al. (2013) [18] described how to balance the load in a particular task using Honey bee behavior by proposing his new algorithm i.e. honey bee behavior inspired load balancing. The proposed technique attains fair load balance over virtual machines so that a maximum throughput is achieved. The proposed technique also deals with the priorities of tasks on machines and balanced those tasks in such a manner that waiting time of tasks is minimized. Here different scheduling algorithms are used to obtain the best performance. Using optimization algorithm response time will be better.

Sung-Soo Kim et al. (2013) [19] proposed a competent BABC (binary artificial bee colony) that contains a FRS (flexible ranking strategy) to get better balance between searching and utilization. For reducing the makespan two different variants are established. Proposed algorithm is enhanced than some other approaches like GA (genetic algorithm), PSO (particle swarm optimization) and simulated annealing. For improving the result of swarm based technique and load balancing ant colony optimization technique is employed.

Gianni Di Caro et al. (1999) [20] presented an overview of recent work on ant colony algorithm. The paper has presented the details about fundamental biological findings on ants and their artificial equivalent with ACO meta-heuristic. The survey also defined the application areas of ACO methods which are used in network communication routing and combinatorial optimization. The survey shows that grouping of algorithms minimizes the makespan of tasks and balances the load as compared to basic ACO and LBACO.

Kansal et al. (2012) [21] proposed load equilibrium technique where the objective of distribution of load is to minimize the resource consumption. This will decrease the rate of carbon emission and energy utilization. The results of proposed algorithm is compared with the existing techniques and it is found that proposed algorithm efficiently balances the load, high delays, and better resource utilization.

III. SOFT COMPUTING APPROACHES

As given in [4] the goals of load balancing are:

a) To improve the performance substantially.

b) To have a backup plan in case the system fails even partially.

c) To maintain the system stability.

d) To accommodate future modification in the system.

Load Balancing has become one of the major key areas for research. There are a number of soft computing techniques available to optimize the load. Here in this paper we will basically deal with evolutionary and swarm optimization tools for load balancing scenario.

A. Genetic Algorithm (GA)

Genetic algorithm (GA) is a search heuristic, based on evolutionary algorithm process of natural selection. This algorithm provides efficient schedules. It involves scheduling heuristic and creates randomized initial population. By using historical information GA exploits the best solutions. GA mainly uses to repeat three steps - selection, crossover, and mutation. At first it defines a set of population i.e. called chromosome, then performs the three steps. In GA a set of

operations and fitness function are used [11]. Steps of GA are as follows:

Algorithm: Basic Steps for GA

1. Initialize a population with randomly generated individuals (chromosome).
2. Evaluate fitness function for each and every individual.
3. Select two chromosomes, as parents which have best fitness value.
4. Apply crossover between the parents with probability and crossover rate.
5. Apply mutation with probability and mutation rate.
6. Repeat Step 3- Step 6, until enough members are generated.
7. Repeat from step 3, until stopping criteria to be met.

1) Algorithm Key Objectives: Load balancing, QoS requirement, task scheduling depends on homogeneous system, energy consumption, minimal cost, find best fit solution.

2) Advantages of Genetic Algorithm in Load Balancing: It can be useful to solve a variety of optimization problems which can be explained by using the chromosome encoding. It can also solve problems with multiple solutions. Since the GA algorithm implementation and execution technique is independent from surface errors, we can solve non-differential, non-continuous, multi-dimensional and non-parametrical problems. Structural GA provides us the possibility to solve the solution parameter and solution structure problems at the identical time.

3) Application Areas of Genetic Algorithm: Genetic algorithm is an interdisciplinary scientific field that develops methods for storing, retrieving, organizing and analyzing biological data. A major activity in bioinformatics is to develop software tools to generate useful biological knowledge. It is generally used in development of Bioinformatics application, forensic science, data mining, image processing, and simulation. Genetic algorithm is also used in discrete mathematics, control theory, system theory, information theory, and statistics.

B. Particle Swarm Optimization (PSO)

PSO is a swarm based heuristic optimization technique. It is developed by observing the social and biological behavior of swarm intelligence i.e. movement behavior of bird flocks and fish flock. The birds are scattered throughout the searching process for food. While the birds are searching for food from one source to other one, there is always a bird from the bird flock that can sense the food source very well. That bird is detectable of the lay where the in the flock are transmitting the information about their location for the food, it helps them to move nearer towards the food source.

Regarding the PSO technique, solution swarm is evaluated to the bird swarm. Better information of the solution from the solution space is equal to the most optimal solution, and the resources of food are equivalent to the most optimal solution throughout the process. General Steps of the PSO algorithm is as follows:

Algorithm: Basic Steps for PSO

1. Initialize population of particles with random position and velocities.
2. Calculate the fitness function value for each and every particle.
3. Compare current particle's fitness value with each particle's fitness value and find Pbest value.
4. Compare population's overall previous best and fitness evaluation and obtain Gbest.
5. Using (1) and (2), update position and velocity of the particle.
6. Check whether maximum number of iteration is completed or not, if not then repeat from step 2.

$$v_i = v_i + c1r1(Pbest - x_i) + c2r2\,(Gbest - x_i) \qquad (1)$$

$$x_i = x_i + v_i \qquad (2)$$

Where, v_i is the velocity for i^{th} particle, x_i is the position of the ith particle. Also, i is the index of the particle. $c1$, $c2$ are constants; $r1$, $r2$ are two random numbers, belongs to (0,1). *Pbest* is the best known position of the particle and *Gbest* is the best known position of the swarm. [23].

1) Algorithm Key Objectives: Minimize the time and communication cost, increase scalability, balances the load of the system.

2) Advantages of Particle Swarm Optimization in Load Balancing: In PSO algorithm task will be assigned to the virtual machine in best fit manner i.e. task will check all the virtual machine and assigns the task to the proper virtual machine which will have least memory wastage.

3) Application Areas of Particle Swarm Optimization: PSO has been successfully used across a wide range of applications, for instance, telecommunications, system control, data mining, power systems, design, combinatorial optimization, signal processing, network training, and many other areas. Nowadays, PSO algorithms have also been developed to solve constrained problems, multi-objective optimization problems, problems with dynamically changing landscapes, and to find multiple solutions, while the original PSO algorithm [24] was used mainly to solve unconstrained, single-objective optimization problems.

C. Ant Colony Optimization (ACO)

Behavior of ants makes them hick insects. The memory of ants is very limited. In the group of ants individual behavior appears as a hugely different element. Ant performs communal

technique to achieve a variety of difficult tasks with good steadiness and reliability, which has become the field of ant colony optimization (ACO). They have especially restricted memory and show entity activities [22, 24] and that have a casual section. Ants perform different difficult tasks reliably and consistently. Though it is basically essential that self-organization, they use phenomenon that similar to overtraining in techniques of support learning [5, 6]. The complex social behaviors of ants have been much studied by science, and computer scientists are now finding that these behavior patterns can provide models for solving difficult combinatorial optimization problems. Basic steps associated with ACO algorithm are:

Algorithm: Basic Steps for ACO

1. Initialize the pheromone
2. While criteria not satisfied, then repeat
3. Initially set locations of all ants on an entry state
4. Selection of next state
5. While not reached to the final state then repeat from step 4, if reached then Step 6.
6. pheromone stages(deposit, daemon and evaporate pheromone
7. Check whether criteria satisfied or not, if satisfied then end, if not then repeat from step 2.
8. End.

1) Algorithm Key Objectives: Minimize the makespan, balance load of the system, reduce time, highly efficient, and improve the ability of balance.

2) Advantages of Ant Colony Optimization in Load Balancing: ACO has a number of advantages with some critical issues that to be determined in order to enhance reliability of the cloud system. Such problems are associated with the fault tolerance, load balancing and variety of security issues in cloud. The load can be memory capacity, load of cpu, network load, network delay etc.

3) Application Areas of Ant Colony Optimization: Ant colony optimization algorithms are useful for combinatorial optimization problems, routing vehicles and some derived methods are adapted to real variable dynamic problems, stochastic problems, multi-targets and parallel implementations.

D. Artificial Bee Colony (ABC)

The ABC technique is deepened on the social behavior aspects of bees i.e. how they do the switch over of information among all bees. By observing the whole hive of bees, we can differentiate some components that usually exist in all hives [6, 7]. The important component of the hive with respect to exchanging knowledge and information is the dancing region. Whole contacts of all bees correlated with the location and food resources quality in the area of dancing [8, 25]. The associated boogie is called waggle dance. Since an onlooker bee has good food sources information and exists on the dance floor, they possibly might look at many boogies and then she opts to make use mainly beneficial source. Steps involved in artificial bee colony algorithm are as follows:

Algorithm: Basic Steps for BCO

1. Initialize the population randomly distributed over solution space
2. Assess the fitness value of each and every individual
3. Calculate the outlooker bee movement probability using equation. 3
4. Check for the fitness value for repeated iteration
5. If fitness value is not improved then do
   a. Discard all food sources
   b. Convert employee bees to Scouts bees using equation. 5
6. Select the best fitness value and its position
7. Check for stopping criteria, if satisfied then stop and exit else go to step 1.

$$p_i = f(v_i) / (\sum^{n}_{i=1} f(v_i)) \quad (3)$$

Here $f(v_i)$ represents the fitness value's of i^{th} solutions as evaluated by the employee bee, n denotes the total number of represents by p_i.

$$S^{r+1}_{ij} = v^{r}_{ij} + \phi^{r}_{ij}(v^{r}_{ij} - v^{r}_{kj}) \quad (4)$$

Here i €1,2,...m and j €1,2,...n are selected indexes in dimension k ($\neq i,j$),and ø(.) is used to generate arbitrary series ranges between[-1,1] within a time r, which is basically controlling the neighbor solution near v_{ij}

$$v_{ij} = v_{jmin} + r.(v_{jmax} - v_{jmin}) \quad (5)$$

where r is a random number between 0&1.

1) Algorithm Key Objectives: Proper utilization of resources, minimum makespan, most favorable scheduling of job, guarantee for local optimal solution and use of greedy mechanism.

*2) Advantages of Artificial Bee Colony in Load Balancing:*It had been initially proposed for numerical optimization. It can be also used for combinatorial optimization problems. It can be used for unconstrained and constrained optimization problems. It employs only three control parameters (population size, maximum cycle number and limit) that are to be determined by the user.

3) Application Areas of Artificial Bee Colony: It provides a very good approach for structural optimization. It provides a

very good solution to MR brain image classification and estimation of face pose.

IV. VARIOUS TECHNIQUES IN TABULAR FORM

TABLE I. TECHNIQUES OF VARIOUS GA

Algorithm	Authors	Key objective	Application areas	Issues
GA based techniques.	Dasgupta, Mandal, Dutta and Dam [9] (2013)	Balancing the load of infrastructure in cloud.	Minimizes the makespan using JUV, fitness function.	Utilizes the resource efficiently and ensures QoS.
GA based heterogeneous system.	Page and Naughton [11] (2005)	Well utilizes the processor of the scheduler.	A huge number of tasks and processors can involve in scheduling procedure.	Minimize the cost for communication, time for execution and makespan.

TABLE II. TECHNIQUES OF VARIOUS PSO

Algorithm	Authors	Key objective	Application areas	Issues
Particle swarm optimization.	Goyal and Bharti [12] (2014)	Optimize the load.	Comparing these techniques with respect to fixed parameters.	Reduces the time for execution and equality of the workloads.
PSO based on virtual machine.	Liu and Wang [13] (2012)	Distribution of loads among virtual machine.	Rate of convergence and the performance of global search is validated.	Optimization of the time for running and utilization of resources.

TABLE III. TECHNIQUES OF VARIOUS ACO

Algorithm	Authors	Key objective	Application areas	Issues
ACO and theory of complex network.	Zhang and Zhang [15] (2010)	Managing the load of distributed system.	Improve many part of the technique and consider the feature of network complexity.	Model is developed for analyzing the quantitativity.
Load balancing based ACO.	Li , Xu , Zhao and Dong [16] (2011).	Balancing load of the system and schedule tasks.	Improve the ability of balancing and loading the virtual machine.	System load balancing dynamically adopted.

TABLE IV. TECHNIQUES OF VARIOUS BCO

Algorithm	Authors	Key objective	Application areas	Issues
Load balancing based on honey bee behavior.	L.D.' and Krishna [18] (2013)	Throughput maximization.	Distributes the load among VMs and give priority to the task.	Manages the utilization of machines, minimum time to wait.
Binary-ABC.	Kim , Byeon , Liu, Abraham and McLoone[19] (2013)	Optimized solution.	Use few parameters for control and spread searching.	Reduces the makespan, better performance.

TABLE V. TECHNIQUES OF VARIOUS OTHER ALGORITHMS

Algorithm	Authors	Key objective	Application areas	Issues
Firefly algorithm.	Florence and Shanthi [10] (2014)	Proper distribution of loads and optimized scheduling.	Efficiently optimizes the schedule by using three simple steps(generation of population, calculation of scheduling index and optimization of list) .	Deals with server in cloud network and give proficient result.
Round Robin algorithm.	Pooja Samal, Pranati Mishra [14] (2013)	Better performance.	Supervise the SP's resources and the load of the central server.	Minimum time for response and proper use of resources.

V. CONCLUSION

Since cloud computing has the potential to effectively handle the future computing requirements, it is necessary to optimally handle the major issues arising during computing over clouds. Load balancing is one such important issue which affects the utilization of resources and performance of the cloud system. So a lot of research work has been done to efficiently balance overall workload over available resources. This paper has surveyed some best evolutionary and swarm based load balancing algorithms with their application areas and their suitability to specific areas. As future work authors will try to identify some more effective

load balancing techniques and focus on mechanism to reduce time taken for load balancing.

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