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Comparative Analysis of Metaheuristic Techniques: Ant Colony Optimization (ACO) and Genetic Algorithm (GA)

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***Abstract*:** cloud computing delivers a service over the network by the use of hardware as well as of software that is the internet. Cloud computing is technology that are rapidly increase in terms of both academia and industry. Cloud computing allows everyone to use software and computing services on-demand at anytime, anywhere and anyplace using the internet. With the help of the cloud computing, users can access the files as well as can use the applications from any other device which can access the internet device. In Scheduling, cloud computing infrastructures contain several challenging issues like time estimation and load balancing etc. But main challenge for cloud computing environment is load balancing. Basically load balancing distributes the load to get lesser makespan (MS) and higher resource utilization. Load balancing algorithms ensure that neither a Virtual Machine is overloaded nor it is under loaded. This paper presents comparison of the metaheuristic approach which is inspired by Ant Behaviors (AB) and Swarm Intelligence (SI): The Ant Colony Optimization (ACO) and The Genetic algorithm (GA).

Key points: Cloud Computing, Load Balancer, The Ant Colony Optimization (ACO), The Genetic Algorithm (GA), Make-span, Resource-utilizations.

I. INTRODUCTION

Today the evolution of technology in the world has given birth to a unique and new concept called Cloud Computing that hosts and offers services and resources to countless number of clients over the internet [1]. Cloud Computing helps to accommodate change in demand and helps any organization in avoiding the capital costs of software and hardware [2].

Cloud Computing definition describes as [3]:

- **The characteristics (Five):** (i) On-demand self-service (ii) Broad network access (iii) Resource pooling (iv) Rapid elasticity and (v) Measured service.

- **The deployment models (Four):** (i) Private Clouds, (ii) Community Clouds (iii) Public Clouds (iv) Hybrid Clouds.

- **The service models (Three):** (i) Software as a Service (SaaS) (ii) Platform as a Service (PaaS) (iii) Infrastructure as a Service (IaaS).

Figure 1 shows architecture of the Cloud Computing which contains cloud services, resources with examples.

The paper is organized as: Section (II) which describes the load balancing and some existing load balancing algorithms. Section (III) presents here most popular Load Balancing Algorithm i.e. Ant Colony Optimization and Genetic Algorithm along with their pseudo code. In Section(IV), simulation of these two Load balancing algorithm have been performed on Cloud Sim, then a comparative analysis based on make-span, resource-utilization and load balancing level (lbl) has been done and result have been presented graphically, the final conclusion is given in section (V).

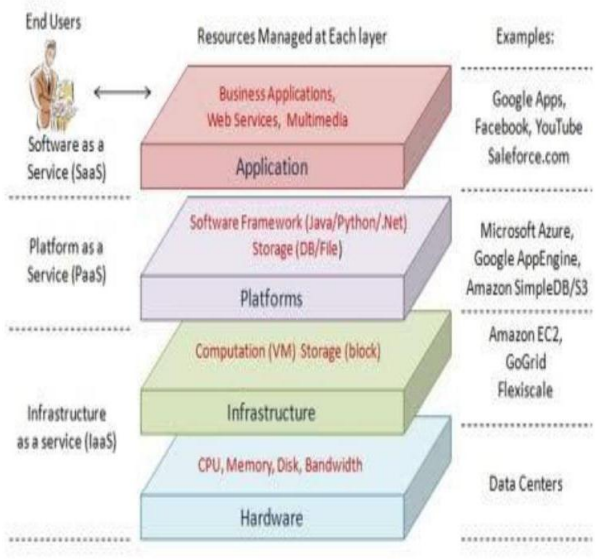

Figure 1: ARCHITECTURE OF CLOUD

II. LOAD BALANCER

Load Balancing in cloud computing environment is really a challenge now. Load Balancing is a performance improving method applied in the area of networking to distribute the work load across multiple resources that are involved in the computation of a networking task. Cloud Computing is a solution for enabling suitable resources access to a shared pool of computing resources [4]. In cloud computing "virtualization" is the main concept. The virtualization is the key technology which makes the Cloud computing possible. Load balancing algorithm is of two types**:-**

1. The Static algorithms (SA): Static algorithms are those which equally divide the traffic between servers.

2. The Dynamic algorithms (DA): Dynamic algorithms are which search for the lightest server in the network and then designated appropriate weights on it.

III. LOAD BALANCING ALGORITHM

In load balancing there are various type of strategies or algorithm have been adopted, which are described under following three categories:

(a) Traditional Techniques: These are the fundamental techniques for scheduling various tasks such that:
(i) First Come First Serve (FCFS).
(ii) Round Robin (RR).
(iii) Shortest job first (SJF) etc. These are the simple techniques and deterministic, but they get stuck in local optima [5].

(b) Heuristic Techniques: Heuristic techniques are used to find near optimal solution by using a sample space of random solution such that
(i) Min-Min.
(ii) Max-Min.
(iii) Enhanced max-min etc. This technique gives better result as compared to the traditional techniques [6].

(c) Meta-Heuristic Techniques: These techniques generally used population based concepts inspired by social behavior of insects such that
(i) Ant Colony Optimization (ACO)
(ii) Genetic Algorithm (GA)
(iii) Particle Swarm Optimization (PSO), (iv) Tabu Search algorithm and
(v) Honey Bee foraging algorithm etc. The difference between Heuristic and meta-heuristic techniques are heuristic techniques are problem specific and meta-heuristic are problem independent [7].

Here two popularly used metaheuristic algorithms as Ant Colony Optimization and Genetic Algorithm have been Presented.

(A) Genetic Algorithm

The basic idea of GA introduced in 1960s by Holland [8]. In this there is an initialization solution of population and then convert to one optimal solution [9]. GA strongest species passes their gene to next or future generation through the process called reproduction as they carry greater opportunity and the process is time consuming process. After a long period of time, the kind of species that is suitable for carry out the matching gene with the help of combination. They are said to be as more dominant [10]. This is the unstoppable believe that new kind or species produces from the previous kind of species, which has unsuccessful changes [11]. Term GA which is solution are called chromosome. Chromosomes are made up of small-small units, known as Genes. Each gene is used to control chromosome more than one or more elements. GA's proposed by Holland, they have genes as binary digits [9]. Then, Gradually individuals of higher fitness finds as the algorithm by running step by step [12]. When standard decided or criterion was met, number of iterations is changed by the algorithm.

Genetic Algorithm (GA) Algorithm
Procedure GA begin
Begin
1. Set the Population;
2. Evolution process;
4. While (No terminations) do

5. Do solutions:
6. Apply crossover;
7. Apply Mutation;
8. Evaluate created solution;
9. End While;

GA is a metaheuristic technique which is used to solve constrained problems as well as unconstrained optimization problems. The GA changes an individual solution. The GA carries randomly solutions from the current solutions which is called Parents and produces Children for the next generation in every step. In the GA population, the best minimum amount point becoming near to an optimal solution. By computation GA chooses next population with the help of using random number generators.

(B) Basics of Ant Colony Optimization (ACO)

The Metaheuristic techniques i.e. Ant Colony Optimization (ACO) algorithm was given by Macro Dorigo in during his PhD (1992), which is inspired by the ant colony behavior of food searching. ACO metaheuristic is inspired by the behavior of real ants is helpful in finding the shortest path between the colonies and food [13]. The Ant Colony Systems is shown in Figure 2. In the first picture, the ants moving one by one from nest to food. Then there is a situation in the second picture which shows that a barrier or obstacle in mid of the nest and the food. By removing obstacle, each ant moves left or right randomly. The ants which move left side will reach the food and ants that move the barrier turning right side will have a largest path. The pheromones build up faster in the shortest path. So result is that the ants which have more amounts of pheromones, that is the shortest path shows in Figure 2.

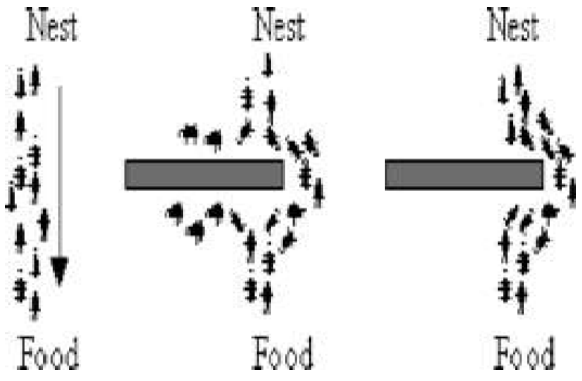

Figure 2: BEHAVIOUR OF ANT COLONY SYSTEM (ACS)

Artificial Ant Colony System is called as a system of agent-based. The ACS put forward by Macro Dorigo in 1992 in his PhD thesis, which is a heuristic technique and suitable for large problems and this heuristic is said to be as Ant Colony Optimization (ACO). Mostly useful result of the global among ants colony system is the cheaper one. Artificial ants are inspired from real ants: they put pheromone mark (i.e. mathematically form).

This pheromone trail which is developed gradually is now decreased by the evaporation. ACO and the classical ant system are differ from each other, the pheromone can be updated as

- **The Local Updating Rule (LUR):** Ants locally changes the amount of pheromone on the edges which they visited while construct a tour.
- **The Global Updating Rule (GUR):** When all the ants having their individual tours for them, then this rule is applied to the modify edges pheromone level. This belongs to be found the best Ant Colony tour so far.

Ant Colony Optimization (ACO) algorithm [14]

Procedure ACO begin
1. Initialize the pheromone value
2. While (stopping criterion not matches) do
3. Position each ant in a starting VM
4. While (stopping when every ant has build a Solution) do
5. for each ant do
6. Choose VM for next task by pheromone trail intensity
7. End for
8. End while
9. Pheromone Updating
10. End while
11. End

ACO algorithms that is applicable for the large problems. ACO has been used for getting near-optimal solutions. For example: Travelling Salesman Problem (TSP). ACO outperforms the algorithm of simulated annealing as well as the genetic algorithm approaches.

IV. SIMULATION BASED COMPARATIVE ANALYSIS ON CLOUDSIM

Simulation of two metaheuristics load balancing algorithm: ACO and GA have been done by using CloudSim as a simulation tool. CloudSim is a one of the famous toolkit that gives framework to check the performance of algorithms. Today, researchers focuses on the designing issues that they wants to carry out, without having any awareness which are related to cloud-based infrastructure and services. Table 1, Table 2 and Table 3 shows that Ant Colony Optimization (ACO) performs better as compared to the Genetic Algorithm (GA) with their graph representation. Experiments have done with the comparisons of the algorithm performances based on

the (i) makespan (ii) Average Resource Utilization (ARU) and (iii) LBL. The makespan, avgRU and LBL are in Table 1, Table 2 and Table 3 on different number of tasks. Their corresponding graphs have been shown in fig. 3, 4 and 5.

- **MAKESPAN (MS): -** MS is the finishing time in the last task. calculated by the formula:

  Ms = maximum (ready time (Rti))

Where Rti: ready time of scheduled resources.
Less makespan scheduling algorithm = Better work performs.

- **AVERAGE RESOURCE UTILIZATION (ARU): -** calculated with the formula relation:

  ARU= Mean (ready time (Rti))/MS * 100

Higher ARU = Better work performance.

TABLE I. Makespan

No. of tasks	ACO-Makespan	GA-Makespan
10	4.9	7.1
30	13.28	25.1
60	22.29	44.1
90	41.21	58.2
120	58.48	95.21

TABLE II. AvgRU

No. of tasks	ACO-RU	GA-RU
10	79.93	70.53
30	89.53	65.19
60	92.65	68.04
90	93.88	49.79
120	97.45	48.65

TABLE III. LBL

No. of tasks	ACO-LBL	GA-LBL
10	71.07	61.45
30	92.3	66.01
60	96.55	45.17
90	95.24	61.9
120	95.34	56.75

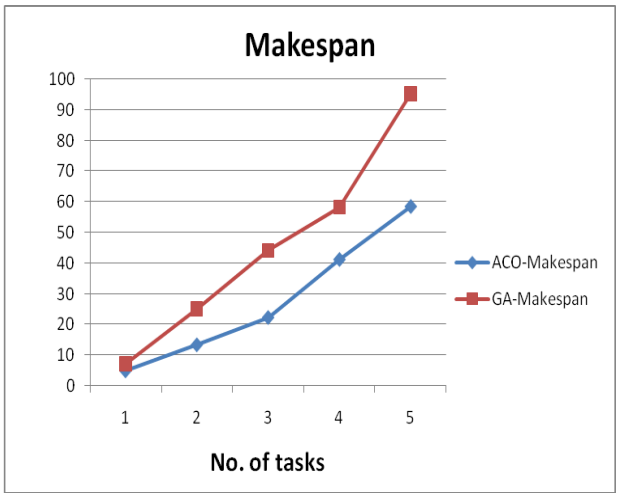

Figure 3: Performance Analysis Using Makespan

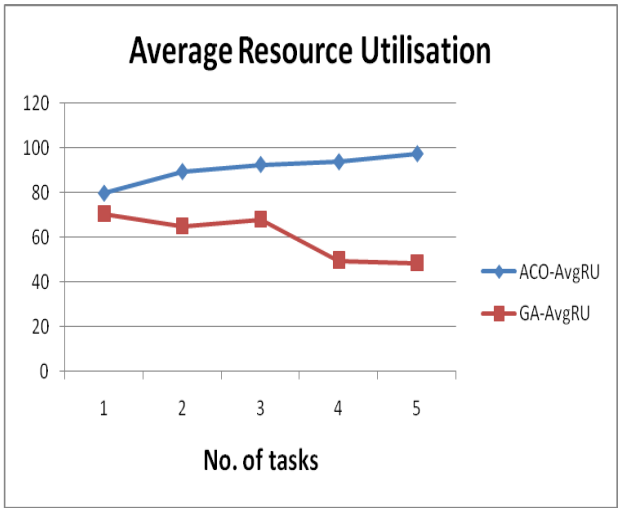

Figure 4: Performance Analysis Using AvgRU

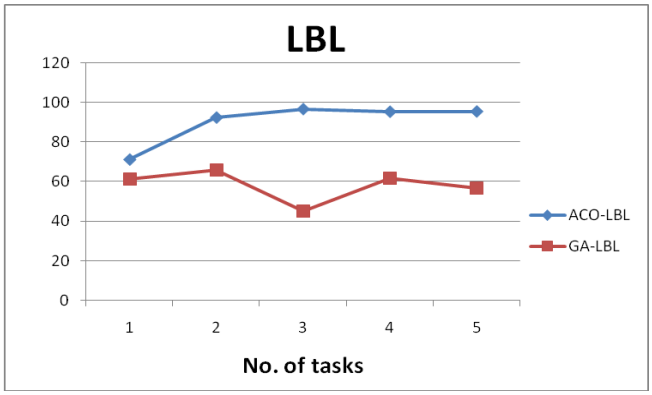

Figure 5: Performance Analysis Using LBL

After comparing these two algorithms it is clearly visible that the ACO load balancer is performing better than the GA load balancer.

Although ACO and GA gives better results in test performances, some of the differences are discussed below.

- GA Algorithm is a fast algorithm and easy to implement.
- GA is applicable only for small computational problems (i.e. small to medium).
- GA is well suited for fast finding of best solutions.
- ACO Algorithm is desire excessive and provides better results.
- ACO is applicable for large computational problems (i.e. large to complex results)
- ACO is well suited for fast finding and of high quality solutions.

V. CONCLUSION

This paper performs a simulation based comparative analysis on two most popularly used metaheuristic algorithms Ant Colony Optimization and Genetic algorithm. It has been observed that Ant Colony Optimization algorithm provides better result as compare to the Genetic Algorithm. Genetic Algorithm (GA) is useful only for small tasks, as the number of task are increases, it will maximize the makespan, which will not required. In case of Ant Colony Optimization (ACO) algorithm they give better results in small as well as in large tasks. Future scope has been focused on the wide scope of improvement in Ant Colony Optimization load balancing algorithm where ACO minimize the makespan and maximize the resource utilization.

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