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An Multiple Pheromone Algorithm for Cloud Scheduling With Various QOS Requirements

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Abstract

The Cloud computing is one of the rapidly improving technologies. Cloud computing is a new promising paradigm in distributed and parallel computing. As cloud-based services become more dynamic, resource provisioning becomes more challenging. One of the critical problems in cloud computing is job scheduling because it increases with the size of the grid and becomes difficult to solve effectively. This paper introduces a new algorithm called Multiple Pheromone Algorithm which is belongs to Ant Colony Optimization Algorithm. The objective of MPA algorithm is to dynamically generate an optimal schedule so as to complete the task in minimum period of time as well as utilizing the resources in an efficient way. In this paper three different Quality of Service (QoS) makespan, cost and reliability constraints are considered as performance measure for scheduling. This algorithm is compared with normal Ant colony algorithm, Genetic Algorithm. With the implementation of this approach, the Multiple Pheromone Algorithm (MPA) Algorithm reaches optimal solution as well as obtains the better QoS than ACO and GA.

Keywords: *Cloud Computing, Job Scheduling, Resource Allocation, Multiple Pheromone Algorithm(MPA)Ant Colony Algorithm(ACO), Genetic Algorithm(GA), QoS constraint.*

1. Introduction

Cloud computing has opened a new era to a shared IT infrastructure in which large pools of systems are linked together via the internet to provide IT services, such as different utility services of our day to day lives like tax calculation web services, weather information web services etc; which are on pay per user basis**.** Cloud computing is a term used to describe both a platform and type of application. A cloud computing platform dynamically provisions, configures, reconfigures, and de provisions servers as needed. Servers in the cloud can be physical machines or virtual machines. It provides the utility services based on the pay-as-you go model. Users can host different kinds of applications on the cloud ranging from simple web applications to scientific workloads. These applications are delivered as services over the internet.

Cloud Computing is capable to provide massive computing or storage resources without the need to invest money or face the trouble to build or maintain such huge resources. The consumers only need to pay for using the services just like they do in case of other day to day utility services such as water, gas, electricity etc, which are on pay per user basis and hence our cloud computing resources are also on pay per user basis. Cloud computing is now being used in many applications that are beyond distribution and sharing of resources. The distributed resources are useful only if the cloud resources are scheduled. Using optimal scheduler's results in high performance cloud computing, where as poor schedulers produce contrast results. Now, the scheduling in cloud is a big topic in grid environment for new algorithm model. Scheduling is a challenging job in cloud because the capability and availability of resources vary dynamically. The goal of job scheduling is to properly dispatch parallel jobs to slave node machines according to scheduling policy under meeting certain performance indexes and priority constraints to shorten total execution time and lower computing cost and improve system efficiency. The demand for scheduling is to achieve high performance computing. It is very difficult to find an optimal resource allocation for specific job that minimize the schedule length of jobs. The scheduling problem is a NP-hard problem [1] and it is not trivial. ACO (Ant Colony Optimization) is one effective method to deal with NP problem, which has stronger robust, distributed capability, parallel and scalability. Cloud computing is a new promising paradigm in distributed and parallel computing. It can offer utility-oriented IT services to users based on a pay-as-you-go model. In Berkeley's View [1], "cloud computing, the long-held dream of computing as a utility, has the potential to transform a large part of the IT industry, making software even more attractive as a service and shaping the way IT hardware is designed and purchased". It can also make good use of economies of scale and dynamically deliver/configure almost any IT related services on demand [2]. Moreover, it can conserve more energy, which is the desirable computing platform for the coming low-carbon economy [3].

Due to so many attractive characteristics, besides those big companies of influential, a lot of companies and colleges [4, 5] started to take this seriously and decided to make good use of it. Before rushing to transplant their services to a third-party commercial cloud [6], most of them chose to apply this new paradigm in their own data centers first, and this is known as private clouds. In private clouds, virtual machine based applications for daily uses are getting popular, such as virtual desktop, virtual classroom and virtual lab. Since private clouds have some unique characteristics and special requirements, it is still a challenging problem to effectively schedule VM requests onto physical servers, especially with multiple objectives to meet, e.g. response time, energy conservation, load balancing and so on. This problem should be considered seriously and carefully, for it can directly affect the flexibility of the system, which is one of the key features of clouds. The problem of VM scheduling has been widely studied in previous researches; however it is always limited in the scenario of cluster computing, grid computing or commercial clouds, and mostly with one or two objectives considered simultaneously.

Variety of approaches is implemented to define optimized scheduler including swarm intelligence. In this paper we derive new algorithm called Multiple Pheromone Algorithm (MPA) which is belongs to Ant Colony Algorithm (ACO) is one of the famous algorithms in swarm intelligence. Remaining section will be discussed by following: In section 2 describes related work, in section 3 detail explain of Multiple Pheromone Algorithm (MPA), in 4th section explain QoS constraints, in 5th section explain Pheromone management, in section 6 detail performance analysis and in section 7 describes the conclusion.

2. Related Work

The potentiality of computing utility was first pointed by Leonard Klein rock[1], one of the pioneer researcher, who seeded the idea of internet. He had predicted long back, regarding the wide use of "computer utilities", finally he came into existence in the form of cloud computing. Resource allocation for clouds has been studied very extensively in the literature. The problem of deciding on an optimal assignment of requests to resources allocate is NP-hard [4]. Several heuristic algorithms have been proposed by researchers for optimal allocation of cloud resources. Li-Shan Chen define swarm intelligence and its importance for cloud computing [13]. The Meta heuristics computing research community has already started to examine the scheduling problem. Ritchie and Levine used Single heuristic approaches for the problem in Local Search [5].

Gouscos etal. [3] Presents a simple approach to model certain web service management attributes using various QoS constraints [3]. S. Venugopal, X. Chu, and R. Buyya describes QoS for resource reservation[10]. K.Mukherjee, he propose Ant Colony Optimization(ACO) for cloud computing[6]. Lskrao Chimakurthi and Madhu Kumar S D, use ACO algorithm in cloud for power efficient resource allocation[7]. Hengliang Shi,Guangyi Bai and Zhenmin Tang define ACO algorithm for job scheduling in computational cloud[8]. Jiandun Li,Junjie Peng and Wu Zhang describes various scheduling algorithm for grid environment[9].Navjot Kaurand his co-authors define various workflow scheduling algorithms for makespan and resource allocation in cloud computing[11]. Sandeep Tayal define genetic algorithm in cloud computing for task scheduling [12].

3. Multiple Pheromone Algorithm(MPA)

The basic idea of ACO is to simulate the foraging behavior of ant colonies. When an ants groups try to search for the food, they use a special kind of chemical to communicate with each other. That chemical is referred to as pheromone. Initially ants start search their foods randomly. Once the ants find a path to food source, they leave pheromone on the path. An ant can follow the trails of the other ants to the food source by sensing pheromone on the ground,. As this process continues, most of the ants attract to choose the shortest path as there have been a huge amount of pheromones accumulated on this path. This collective pheromone depositing and pheromone following behavior of ants becomes the inspiring source of ACO. In this paper we introduce a new type of Ant Colony Clustering called Multiple Pheromone Algorithm(MPA) to tackle the scheduling problems in cloud computing. It is similar to Ant Colony but has three major difference.

Firstly, Ants use different pheromone value for each task so that Ant Colony Algorithm become to Multiple Pheromone Algorithm. Secondly, MPA using this multiple pheromones values to select task for different resources. Thirdly, it work by the parallel combination of heuristic information. Multiple Pheromone Algorithm can be viewed by the following procedures.

- *Initialization of algorithm :* All pheromone values and parameters are initialized at the beginning of the algorithm.
- *Initialization of ants:* M number of ants are initialised to select N number of task. Each ant build solution to M number of resources. In each iteration ants are randomly selected to build a constructive direction .
- *Local Pheromone Updating:* After M ants map solution to M number of resources ,pheromone value is updated by local pheromone updating rule.
- *Multiple Pheromone Updating:* If an ant select a new task and pheromone value is increased by ρ is a parameter to improve the efficient allocation.

- *Solution Construction:* M ants build solution to M resources using the selection rule based on pheromone and heuristic information.
- *Global Pheromone Updating:* After M ant build solution at the end of the iteration for next iteration pheromone value is updated by using global pheromone value to find best-so-far solution.
- *Final Solution:* At the end of iteration find the best solution from the result of completed iterations.

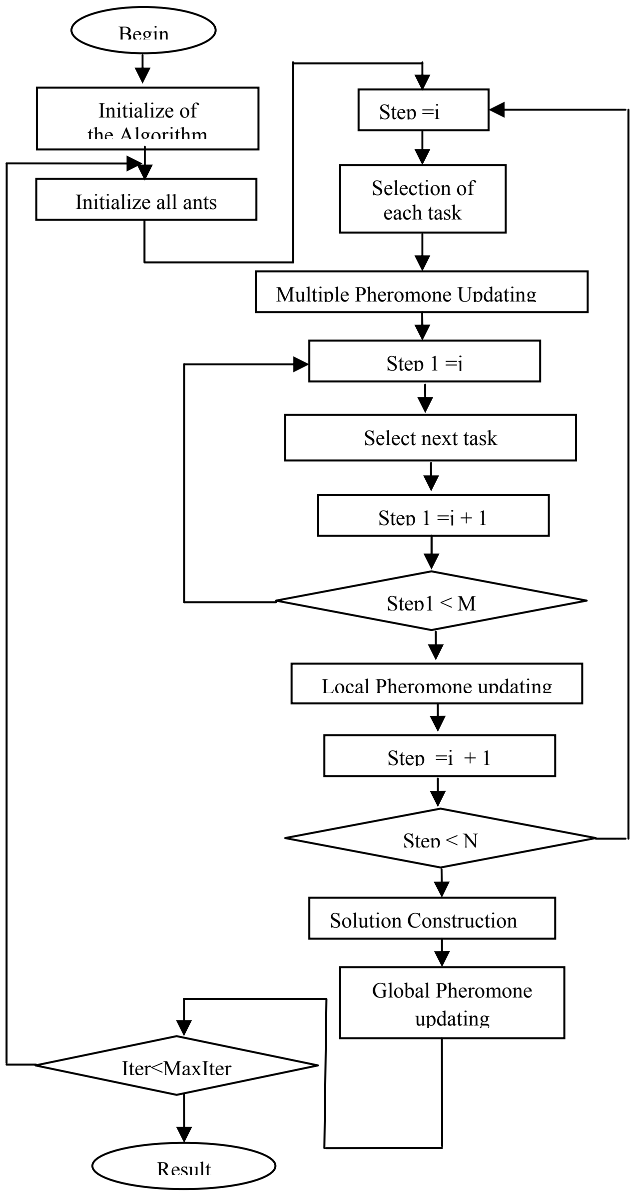

Figure 1. Flow chart for Multiple Pheromone Algorithm(MPA)

Cloud computing is a term used to describe both a platform and type of application. A cloud computing platform dynamically provisions, configures, reconfigures, and de provisions servers as needed. Servers in the cloud can be physical machines or virtual machines. Advanced clouds typically include other computing resources such as storage area networks , network equipment, firewall and other security devices. Cloud computing also describes applications that are extended to be accessible through the Internet.

These cloud applications use large data centers and powerful servers that host Web applications and Web services. Anyone with a suitable Internet connection and a standard browser can access a cloud application. The cloud computing architecture is built upon several functional component blocks. The width of these layers represents the depth of technical expertise required to build and deploy that layer.

4. Ants Based QOS Constraints

Ants in MPA are constructed by fitness value based on three QoS constraints such as makespan, cost and reliability.

A. Heuristic Information

Heuristic referred as some method based values used to guide ants search direction. Heuristic Information value is calculated based on these QoS constraints. If an ant choose makespan constraint then heuristic value is evaluated by makespan or if an ant choose cost then heuristic value depend on cost constraint and it is similar for reliability constraint.

1. Makespan Constraints

Condition for makespan constraint is total execution time must not be larger than a user defined variable Deadline. The task with the minimum time has the greater priority to be chosen. Initialization of ants with makespan then the heuristic information is defined by

$$\eta_i^j = \frac{Max.Makespan_i + R_i^j.Cost + 1}{(Max.Makespan_i - Min.Makespan_i) + R_i^j.Cost + 1}$$

By above equation, η_i^j is defined as heuristic value which i^{th} task is mapped to j^{th} resource. Here, task with minimum time hold higher priority and assigned to j^{th} resource and the value of η_i^j € (0,1).

2. Cost Constraints

Condition for cost constraint is total cost of the resource must be larger than a user defined variable budget. The task which hold minimum cost has the greater priority to be chosen. Initialization of ants with cost constraint then the heuristic information is defined by

$$\eta_i^j = \frac{Max.Cost_i + R_i^j.Cost + 1}{(Max.Cost_i - Min.Cost_i) + R_i^j.Cost + 1}$$

As by above equation, task with minimum cost has chosen first and assigned to j^{th} resource and the value of η_i^j€(0,1).

3. Reliability Constraints

Condition for reliability constraint is total reliability of the resource must be larger than a user defined variable. The task which contain maximum reliability to be chosen first. Initialization of ants with reliability constraint then the heuristic information is defined by

$$\eta_i^j = \frac{Max.Reliability_i + R_i^j.Rel + 1}{(Max.Reliability_i - Min.Reliability_i) + R_i^j.Rel + 1}$$

As by above equation, task with maximum reliability has chosen first and assigned to j^{th} resource and the value of η_i^j€(0,1).

5.Pheromone Management

Pheromone is some kind of chemical released by ant while searching for food. In general pheromone is used to record the searching experience in ants behavior.

1. Pheromone Initialization

At the beginning of algorithm, we set all pheromone value to an initial value τ_0 as

$$\tau_i^j = \tau_0 , \quad 1 \le i \le N \text{ and } 1 \le j \le M;$$

where $\tau_0 = \frac{Max.Length}{Min.Length}$, Min_Length is the minimum length of the task and Max_Length is the maximum length of the task.

2. Multiple Pheromone Updating

Before selecting each task pheromone updating is taken place called multiple pheromone updating is used to improve the efficiency of resource allocation. It is obtained by adding the pheromone value by parameter ρ.

$$\tau_i^j = \tau_i^j + \rho.$$

Where ρ is the value within a range 0 to 1.The value of ρ is selected randomly by ant at the time of task selection.

3. Local Pheromone updating

After each ant found solution to each resource, then the local pheromone updating rule is applied to attract later following ants. The local pheromone updating rule is given by an following equation:

$$\tau_i^j = \rho\tau_0 + \rho\tau_i^j$$

In $\rho \in (0,1)$ is a parameter. As τ_0 is the minimum value of all pheromone values, the function of the local updating rule is to increase the value of τ_i^j to enhance diversity of the algorithm. To simulate the phenomenon of pheromone evaporation in real ant colony systems, the amount of pheromone associated with each ant, which does not occur in the constructed rule must be decreased,. The reduction of pheromone of an unused term is performed by dividing the value of each τ_i^j by the summation of all τ_i^j.

4. Global Pheromone updating

Global pheromone updating is only applied at the end of each iteration. Global value is updated by K value which is n task mapped to M resource at each iterations. The global pheromone value is updated by

$$\tau_i^{K_i} = \rho\tau_i^{K_i} + (1-\rho)\tau_i^{K_i} + \tau_0$$

In this equation $\rho \in (0,1)$ is same parameter used in local pheromone updating. The global pheromone updating used to increase the pheromone values associated with the best-so-far solution so that these mappings will be more attractive in future iterations.

5. Solution Construction

Each ant constructs solution by mapping N number of tasks to M number of resources. Solution is constructed by the combination of heuristic and pheromone value. The selection rule of mapping task to resource is given by

$$R_i^j = \tau_i^j \beta^{\eta_i^j}$$

Here, $\beta \ge 1$ is a parameter to determine the relative influence of pheromone and heuristic information. Heuristic values of each state mentioned above that satisfy $\eta_i^j \in (0,1)$ so the values of $\beta^{\eta_i^j}$ satisfy $\beta^{\eta_i^j} \in (0,1)$.

6. Result and Discussion

MPA Algorithm is developed and the result is compared with ACO and GA. The Comparison of MPA ,ACO and GA is done using various ranges of Task Length, Resource Speed. The proposed and existing methods are simulated for various combinations of heterogeneity of task and resources with different ETC Matrix such as 128 x 8, 256 x 16, 512 x 32, and 1024 x 64. Here, 128, 256, 512, 1024 represents number of tasks and 8, 16, 32, 64 represents number of resources. The result was compared with different QoS such as Makespan, Cost and Reliability. Multiple Pheromone Algorithm gives less makespan and cost and it gives high reliability as compared with Ant colony Optimization and Genetic Algorithm. MPA approximately gives a reduction of 4.5% for makespan and cost and approximately 4.5% to 5% increase in reliability compared to GA in most of the cases and it approximately gives a reduction of 2% to 3% for makespan and cost and approximately 1.5% to 2% increase in reliability compared with ACO. Below are the comparison result performed by using task length 1000-2000 MI(Million Instructions) and 5001-10000MI and resource speeds are 0-2 MIPS(Million Instruction Per Seconds) and 5-10 MIPS

TABLE 1: Performance Comparison of ACO and GA with proposed MPA using Task Length as 1000-2000 MI and Resource Speed as 0- 2 MIPS

Scheduling Algorithm	Resource Matrix	Makespan	Cost	Reliability
GA	128 x 8	72365.2358	65236.2560	56390.7856
ACO		63258.4563	60256.5863	54639.5872
MPA		54589.2365	54863.3654	51206.2578
GA	256 x 16	61256.2587	67428.2037	69369.5869
ACO		59863.2547	63256.7856	64258.7512
MPA		59256.4785	58452.0236	60254.8530
GA	512 x 32	80235.4521	74289.2506	76369.5863
ACO		75236.2548	75289.3657	76256.7520
MPA		69586.2356	76358.7520	78256.1256
GA	1024 x 64	70236.5896	79635.2509	79568.0235
ACO		69365.1258	78364.2586	75632.0254
MPA		67536.7856	74213.8546	72156.0458

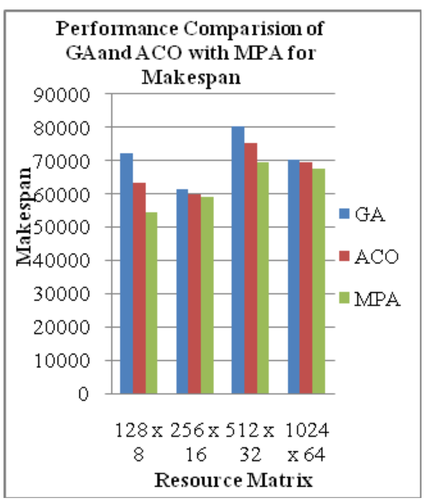

Fig2. Makespan Comparision for Table 1

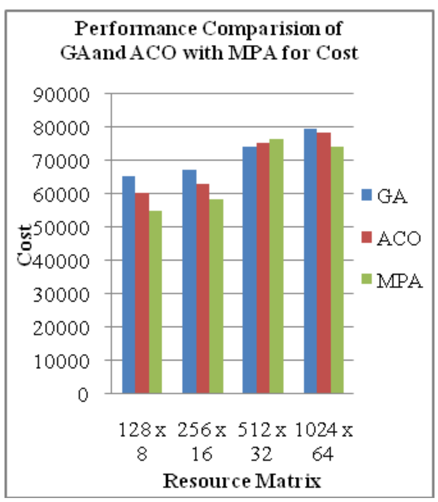

Fig3. Cost Comparision for Table 1

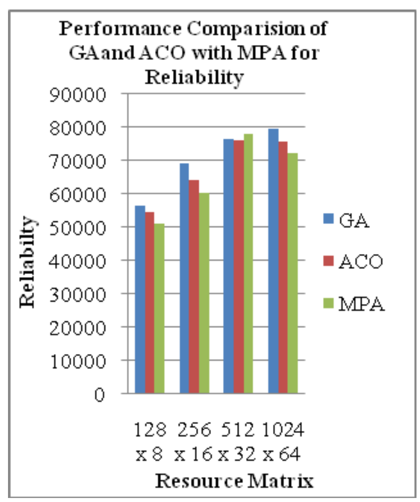

Fig4. Reliabilty Comparision for Table 1

TABLE 2: Performance Comparison of ACO and GA with proposed ABC using Task Length as 50001-10000 MI and Resource Speed as 5-10 MIPS

Scheduling Algorithm	Resource Matrix	Makespan	Cost	Reliability
GA	128 x 8	938635.2356	985633.5869	945879.2586
ACO		937589.0806	965895.1203	936988.2546
MPA		860042.5367	936589.1258	902563.1934
GA	256 x 16	984566.2587	1089637.2304	1145233.2533
ACO		975635.2589	1001254.4523	1123658.6985
MPA		963633.2358	995666.4562	1102548.0256
GA	512 x 32	1096355.2586	1125667.2358	1256334.8523
ACO		1025698.2365	1075699.2546	1196254.5632
MPA		996369.2589	1025635.0125	1110236.4523
GA	1024 x 64	1102569.0254	1123879.5874	1120563.4213
ACO		1123566.7856	1136589.1269	1156321.0863
MPA		1002563.5860	1089633.1458	1096652.0008

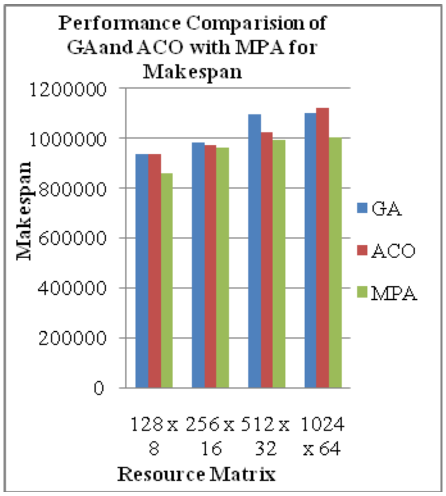

Fig5. Makespan Comparision for Table 2

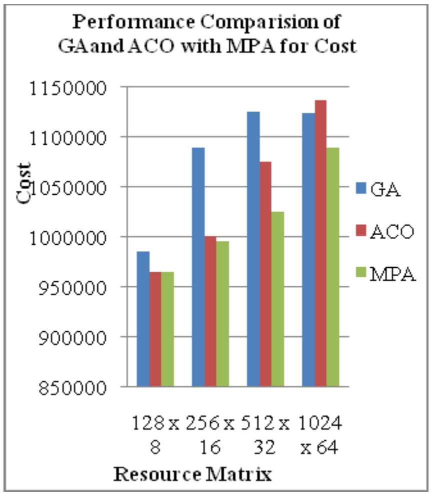

Fig6. Cost Comparision for Table 2

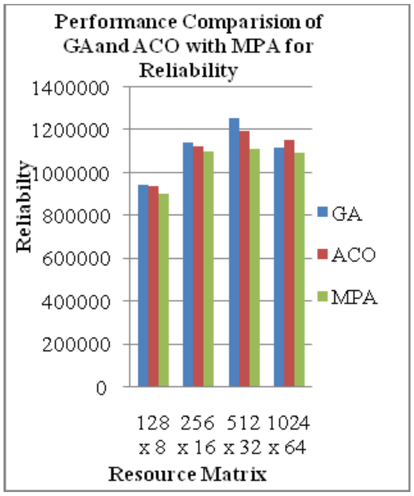

Fig7. Reliabilty Comparision for Table 2

7. Conclusion

In this paper we proposed a new algorithm to Ant based algorithm called Multiple pheromone algorithm. Key features of this algorithm is to find task for resources by the combination of pheromone value and heuristic information. The major objective of scheduling is to reduce the makespan. In this algorithm maximum number of iteration is used to found better optimal solution. MPA algorithmis based on three QoS constraints reliability, cost and makespan. Result shows MPA algorithm is better than other two algorithms ACO and GA. MPA algorithm obtain better solution for low and high matrix. Future work will continued on using deadline and load balancing constraints.

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