Task Scheduling Based on Ant Colony Optimization in Cloud Environment

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Abstract. In order to optimize the task scheduling strategy in cloud environment, we propose a cloud computing task scheduling algorithm based on ant colony algorithm. The main goal of this algorithm is to minimize the makespan and the total cost of the tasks, while making the system load more balanced. In this paper, we establish the objective function of the makespan and costs of the tasks, define the load balance function. Meanwhile, we also improve the initialization of the pheromone, the heuristic function and the pheromone update method in the ant colony algorithm. Then, some experiments were carried out on the Cloudsim platform, and the results were compared with algorithms of ACO and Min-Min. The results shows that the algorithm is more efficient than the other two algorithms in makespan, costs and system load balancing.

Key words: task scheduling; cloud computing; makespan; load balance.

Introduction

Cloud computing is the latest computing model for a variety of applications, data and IT services over the web [1]. At present, cloud computing is applied to all walks of life in society. In the specific implementation process of cloud computing, task scheduling or resource scheduling is an unavoidable link, which directly determines the efficiency of the whole system. The cloud computing system has a large scale of resources, heterogeneous resources, wide user base, different types of application tasks, QoS target constraints are different, cloud computing systems have to deal with a large number of user tasks and massive data [2]. Therefore the cloud computing task scheduling strategy has been the hot spot that is difficult to study, and we need an efficient algorithm for task scheduling in the cloud environment [3]. A good task scheduler should adapt its scheduling strategy to the changing environment and the types of tasks [4]. And task scheduling problems are a typical NP-hard problem. Therefore, a dynamic task scheduling algorithm, such as ant colony optimization (ACO), is appropriate for clouds. ACO can be used to solve many NP hard problems such as traveling salesman problem [5], graph coloring problem [6], vehicle Routing and scheduling problems [7].In this paper we proposed a Multi-objective Optimization Algorithm for Cloud Computing Task Scheduling Based on Improved Ant Colony Algorithm (MO-ACO) to find the optimal resource allocation for each task in the dynamic cloud System which minimizes the makespan and costs of tasks on the entire system, and balance the entire system load. Then, this scheduling strategy was simulated using the Cloudsim toolkit package. Experimental results compared to Ant Colony Optimization (ACO) and Min-Min showed the MO-ACO algorithm satisfies expectation. The organization of paper is as following. Section II introduces the related work. Section III introduces a cloud model and presents the problem statement of the multi-objective task scheduling. Section IV details the proposed MOACO algorithm. Section V presents the simulation results. Finally, Section VI concludes this paper.

RELATED WORK

At present, the cloud computing task scheduling mechanism has not yet formed a unified standard and norms. Many scholars have studied the task scheduling from the makespan, the optimal span, the cost, the reliability, the energy consumption and so on as the optimization goal according to the characteristics of cloud computing task scheduling.[8] focus on virtual machine load balancing, and propose a cloud computing task scheduling algorithm based on load balancing ant colony optimization algorithm. [9] proposed a task scheduling algorithm based on improved particle swarm, which takes into account the total task completion time and the total task completion cost, but does not consider the system load balancing. [10] focus on multi-dimensional QoS, and propose a multidimensional QoS cloud scheduling algorithm based on immune clone to meet the resource load and user's time requirement. [11] proposed based on ACO and CUCKOO hybrid algorithm to reduce the task execution time. A multiinput multi-output feedback control of dynamic resource scheduling algorithm was proposed [12] to guarantee optimal effectiveness under time constraints. This algorithm considers the task execution time, cost, and utilization of resources (CPU, Memory). The paper [13] proposes a multi-objective task scheduling method by minimizing makespan and costs in a heterogeneous multi-cloud environment

MODEL AND PROBLEM STATEMENT

Task Scheduling Model

Cloud computing task scheduling can be described as the allocation of n independent tasks assigned to m virtual machine implementation, which according to the optimization objectives to achieve, build a match between tasks and virtual machine to achieve optimal scheduling. In order to simplify the complexity of the scheduling process, make the following assumptions: 1) The tasks are independent of each other and there is no dependency before or after 2) The unit cost of running the task on each resource is known 3) The task is not interrupted during execution Figure 1 shows the process of task scheduling.

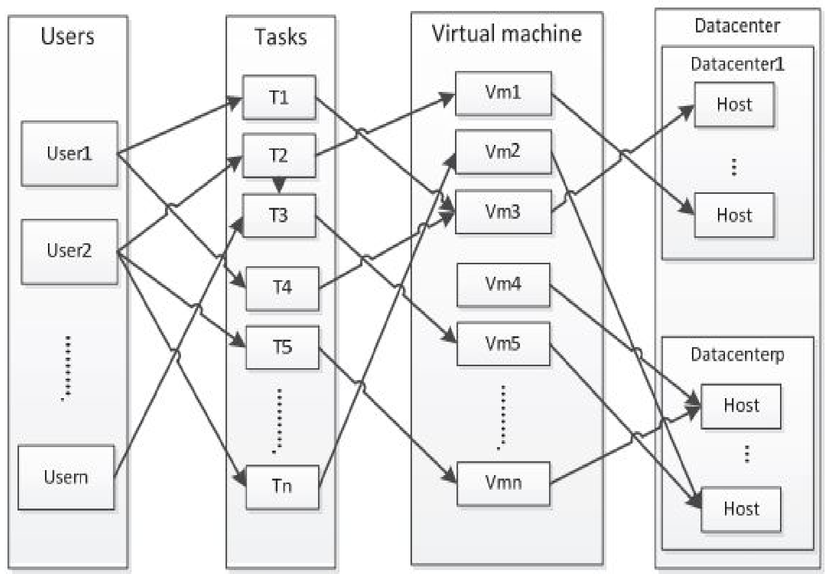

FIGURE 1. Task scheduling process

Figure 1: Task scheduling process

Problem Statement

Task set is defined as T=t1,t2,...,tm,m represents the number of tasks. The virtual machine collection is defined as VM=vm1,vm2,...,vmn, n represents the number of virtual machines. The matching relationship of a task on a virtual machine can be represented by a matrix M:

$$et_i j = \frac{t_{lenghti}}{v_{compj}} \tag{1}$$

$$TaskRuntime_{ij} = et_{ij} + er_{ij} \tag{2}$$

$$\mathbf{vm}_{completetime} = \sum_{i=1}^{k} TaskRuntime \tag{3}$$

MULTI - OBJECTIVE OPTIMIZATION OF CLOUD COMPUTING TASK SCHEDULING BASED ON IMPROVED ANT COLONY ALGORITHM

The ant colony optimization is a heuristic bionic algorithm proposed by Italian scholar M.Dorigo, which is mainly used to solve the optimal solution of combinatorial optimization problem. And cloud computing task scheduling problem has been proved as NP-Hard problem, so the ant colony algorithm used in cloud computing task scheduling can greatly improve the scheduling efficiency. In this paper, based on the study of the standard ant colony algorithm, it is applied to the cloud computing task scheduling to re-establish the model. In the algorithm, each ant looks for the appropriate virtual machine for the corresponding task. The ants finally find an optimal matching scheme according to the optimized target. The ants find the optimal solution in parallel, and communicate with each other through information. We adjust the pheromone on the task with the virtual machine path, which affects the selection of the ant for the other ant and the next iteration for the ant. In this paper, the initial pheromone, heuristic function and pheromone update rule of ant colony algorithm are improved by combining the objective function to be optimized.

Programming Steps of the proposed MO-ACO

- Step1. Initialize the pheromone .Set the maximum number of iterations, the pheromone energetic factor I, the expected heuristic factor , the volatile factors U and U1 , the number of ants m, and p0 .
- Step2. Place all ants at the starting VMs randomly.
- Step3. Each ant calculates the probability of the current task selected on each virtual machine in the set of optional virtual machines based on the formula (20) (21). And then the ant chooses the matching VM for the current task according to the roulette method. And then add the selected VM to the taboo table.
- Step4. When an ant completes a solution, update the pheromone on the matching scheme path found by the ant according to formula (24), (25). Compare with the previous optimal solution and update the optimal solution.
- Step5. If all the ants end their tour, Nc = Nc + 1(Nc is the number of iterations), calculate the global optimal solution and update the pheromone on on the optimal solution path according to formula (26), (27); otherwise, repeat Step3.
- Step6. If the current number of iterations is less than the maximum number of iterations, Clear taboo table and return to Step2. Otherwise, end the iteration and output the best solution.

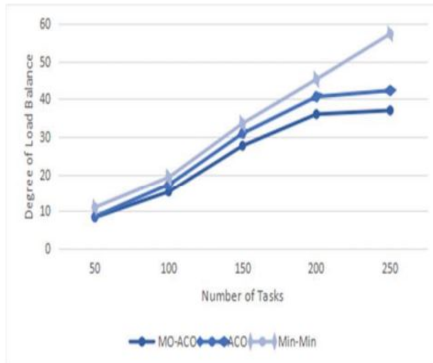

Figure 2: THe total cost

IMPLEMENTATION EXPERIMENTAL RESULTS

In order to verify the effectiveness of the algorithm, this study has done a simulation experiment in the open source cloudsim cloud simulation platform. And compared with the ACO algorithm and Min-Min algorithm.

Parameters setting of the basic ACO and MO-ACO

The parameters of the algorithm are referenced to the paper [15].At the same time we tested and compared the performance of 10 groups of different I, and U parameters. Then we choose the best set of parameters as the parameters in experiments. The parameters' setting is shown in Table 2.

Table 1: Parameters setting of MO-ACO

Parameter hline α	Values 1
β	5
ρ	0.4
ρ_1	0.5
Number of ant (m)	10
q_0	0.9

Experimental results

In the cloudsim, set the same environmental parameters as the premise, we simulate the Min-Min, ACO algorithm and MO-ACO algorithm respectively. In the three aspects of makespan, cost and load balance, three algorithms have been compared respectively. The experimental results are shown in Figures 2 to 4

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