A resource schedule method for cloud computing based on chaos particle swarm optimization algorithm

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Abstract

In order to improve the cloud computing resource scheduling efficiency, this paper proposed a method for cloud computing resource schedule based on chaos particle swarm optimization algorithm. Firstly, the resource scheduling options were taken as the position of the particle, and resource load balancing was taken as the objective function. Then the optimal resource scheduling solution was obtained by sharing information and the exchange of particles, while chaos mechanism was introduced to guarantee the diversity of particle swarm to prevent appearing premature convergence and local optimal solution. The simulation test was carried out in CloudSim platform, and the results show that the proposed method can quickly find the optimal scheduling solution for cloud computing resources and improve the efficiency of resource, and the method has better practicability and feasibility.

Keywords: cloud computing, resource scheduling, chaotic particle swarm optimization algorithm

1 Introduction

Cloud computing covers the virtualization, grid computing, network storage, and distributed computing technology, Using virtualization technology to virtualize the whole server as a resource pool to provide various services for the users [1]. The cloud resource scheduling is one of the core technologies in cloud computing, its efficiency affects Cloud computing systems performance directly, so it is crucial how to find an efficient and reasonable computing resource scheduling model. It determines the performance of cloud computing systems and develops an important research direction in the current [1, 2].

In 2009 based on greedy algorithm NimBus and others put forward cloud computing resource scheduling model. This model is simple but it is difficult to meet the increasing scale of cloud computing [3]. Then at the university of Melbourne Alexander put forward intergrid cloud computing resource scheduling model; in domestic, TianGuanhua, LvLianggan and others put forward dynamic resource scheduling model. These models improved the certain degree of efficiency for the cloud computing resource scheduling [4-6]. Following the development on the bionic intelligent algorithm many scholars put forward based on the genetic algorithm, particle swarm optimization (PSO) algorithm, immune evolutionary algorithm, ant colony algorithm, Leapfrog algorithm etc. cloud computing resource scheduling model. These bionic intelligent algorithms have a lot of advantages: stronger search ability, parallelism, etc.; finding the optimal scheduling scheme on Cloud computing resources quickly. These elements can effectively improve the efficiency for using cloud computing resources [7-9]. However, in actual application bionic intelligent algorithms are easily trapped some defects: local optimal solution, convergence speed etc. Sometimes it cannot obtain the optimal resource scheduling scheme, so it is necessary to improve and perfect the bionic intelligent algorithm, improve the efficiency on cloud computing resources.

In order to obtain better cloud computing resource scheduling scheme, improve the efficiency on computing resources, the paper puts forward a kind of cloud computing resource scheduling scheme that base on chaos particle swarm optimization (chaotic particle swarm optimization algorithm, CPSO), and verify its performance through the simulation.

2 The description for cloud computing resource scheduling problem

Compared with traditional distributed computing platform the advantage of cloud computing is virtualization technology. In cloud computing systems resources have been abstracted into the same virtual resource. Due to different virtual information demand of users and the difference of physical resources, how virtual resources are evenly schedule to the physical resource is a difficult problem in the study of cloud computing system. By certain strategies, resource scheduling is to reasonably schedule the virtual resources to physical resources. In a

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real cloud computing environment, a virtual resource can be abstracted to a certain attribute node. For example, a virtual resource with the properties of internal storage, CPU, or band width can be abstracted as $v(m,c,b)$, in which m represents the properties of internal storage, c represents the properties of CPU, b and represents the properties of broadband. A physical resource can also be abstracted as $p(m,c,b)$.

Cloud computing resource scheduling is a scheme, which refers to schedule the virtual resources in cloud computing environment to physical resources. Corresponding to the virtual resource m_{vi}, c_{vi}, b_{vi} v_i=1,2,...,m and physical resources $p_i(m_{pi}, c_{pi}, b_{pi})$ p_i=1,2,...n, a cloud computing resource scheduling can be represented by the permutation $L(p_{i1}, p_{i2}, \dots p_{im})$, which consisted by m resources. That the virtual resources c_{v1} be scheduled to physical resources p_{i1}, virtual resources c_{v2} be scheduled to physical resources p_{i2} and so on. A large number of studies have shown that cloud computing resource scheduling is a NP problem, if using traditional exhaustive algorithm to solve all possible cloud computing resources scheduling problem, the algorithm's time complexity is $0(n^m)$ [10].

3 Cloud computing resource scheduling solution of CPSO

3.1 THE PARTICLE SWARM OPTIMIZATION ALGORITHM

In the particle swarm optimization algorithm (PSO), this paper regarded the particles as a feasible solution in the problem space. Through itself and company information to guide particles to fly in the multidimensional space of the solution, finally find the optimal position of particles. The updated formula of particle's velocity and position formula is as the following:

$$V_{id}(i+1) = \omega \times v_{id}(i) + c_1 \times rand() \times (P_{best} - X_{id}(i) + c_2 \times rand() \times \left(g_{best} - X_{id}(i)\right), \tag{1}$$

$$X_{id}(i+1) = X_{id}(i) + V_{id}(i+1). \tag{2}$$

Among them, both of c_1 and c_2 are accelerating factor, $v_{id}(i)$ and $V_{id}(i+1)$ is the particle current speed and the updated speed respectively; $x_{id}(i)$ and $X_{id}(i+1)$ is the particle current position and the updated position respectively, ω represents the inertia weight; *rand()* is the random number function of (0,1).

3.2 THE CHAOS PARTICLE SWARM OPTIMIZATION ALGORITHM

A large number of studies have shown that when a specific particle found a local optimal solution in PSO, it will produce attract to other particles. In this way the other particles will soon flying next to the particle, this will appear some defects: the particle swarm prematurity and local optimal solution etc. In order to avoid disadvantages of PSO, using the uncertainty and randomness of chaotic theory and improving PSO by Chaotic mutation operator to generate the Chaos Particle Swarm Optimization algorithm (CPSO). The work thought of CPSO as follows: in the process of particle's flying, to execute chaotic mutation for the history optimal solution of the particle swarm g_{best} in order to prevent the particle position convergence and make the other particles to jump out of local optimal solutions as soon as possible. Specific as follows:

The Logistic mapping Equation represents as

$$Z_{n+1} = 4Z_n(1 - Z_n), \tag{3}$$

where, Z_n represents chaotic variables.

According to the principle of chaos, to add chaos disturbance to that is:

$$Z'_k = (1-\alpha)Z^* + \alpha Z_k, \tag{4}$$

where, $\alpha \in [0,1]$, it represent the strength of disturbance, Z_k and Z'_k respectively represent chaos vector at the iteration k times and after adding disturbance.

Adopting the strength of the disturbance to execute α adaptive value, at the beginning of the search, its value is bigger and strengthen the disturbance to solution vectors, then slowly decreases, and the specific changes as follows:

$$\alpha(k) = 1 - \left(\frac{k-1}{k}\right)^n. \tag{5}$$

3.3 THE DESIGN FOR CLOUD RESOURCE SCHEDULING MODEL OF CPSO

3.3.1 Particle coding

Cloud computing resource scheduling refers to search all possible scheduling along the column to find an optimal scheduling scheme in the end. Set the serial number of cloud computing resources as v_i=1,2,...,m. The physical resource Numbers in Cloud system is p_i=1,2,...n. In order to facilitate calculation and to improve the effect of particle swarm search, this research uses the sequence numbers as particle coding plan. The first step is to sort the cloud computing resources needed scheduling, set as $(v_1, v_2, \dots, v_m)$, then according to the sort to execute scheduling for cloud computing resources scheduling. Set the scheduling sequence as $(v_{a1}, v_{a2}, \dots, v_{am})$, among them, $v_{ai} \in p_i$, then the scheduling model corresponds to v_i, i=1,2,…,m, as for the mapping physical resources, the encoding style in the v_{ai} algorithm is $(v_{a1}, v_{a2}, \dots, v_{am})$.

3.3.2 The original particle swarm

The population initialization is the first step on the particle swarm optimization (pso) algorithm, which is also the most critical step; the fine particle swarm can save more computing time. However, basic particle population usually adopts random way to produce the initial particle swarm. In this case, the probability of larger particles to focus on a local area will become larger; as a result the feasible solution will distribute unevenly and easy to appear local optimal solution, therefore, the study adopts the homogenization method to produce initial particle swarm.

3.3.3 The moderate function design

In cloud computing systems, the goal about resource scheduling optimization is to make the load balancing on all kinds of resources, so to evaluate the performance of a scheduling scheme, the main method is to evaluate whether the scheme can meet the demand of load balancing. For a particle, that is, a feasible cloud computing resource scheduling scheme $(v_{a1}, v_{a2}, \dots, v_{am})$, the balancing degree of CPU, memory, bandwidth respectively defined as follows:

1) The equilibrium degree of CPU properties. Set

$\Gamma_{ctotal} = \sum_{i=1}^{m} c_{vi} / \sum_{i=1}^{n} p_{vi}$,

$\Gamma_{ci} = \sum_{i=1}^{m} c_{vai} / c_{pi}$.

Then the balance of degree about CPU properties is:

$$p_c = \sqrt{\sum_{i=1}^{m} (\Gamma_{ci} - \Gamma_{ctotal})^2}. \quad (6)$$

Among them, $c_{vai} = \begin{cases} c_{vi}, \alpha_i = 1 \\ 0, \ \text{otherwise} \end{cases}$.

2) The balance of degree about memory properties

$$p_m = \sqrt{\sum_{i=1}^{m} (\Gamma_{mi} - \Gamma_{mtotal})^2}. \quad (7)$$

3) The balance of degree about bandwidth properties

$$p_b = \sqrt{\sum_{i=1}^{m} (\Gamma_{bi} - \Gamma_{btotal})^2} . \quad (8)$$

In this way the optimal cloud computing resource scheduling optimal solution is to make the minimum attribute with CPU, memory and bandwidth resources change, so the fitness Fit(i) is defined as:

$$\mathrm{Fit}(i) = a \times p_c + b \times p_b + m \times p_m \quad (9)$$

In the Equation, $a + b + m = 1$ c, b, m indicates the importance of CPU, memory, bandwidth, respectively.

3.3.4 The cloud computing resource scheduling process of CPSO

The CMP task scheduling process of CPSO is shown in Figure 1.

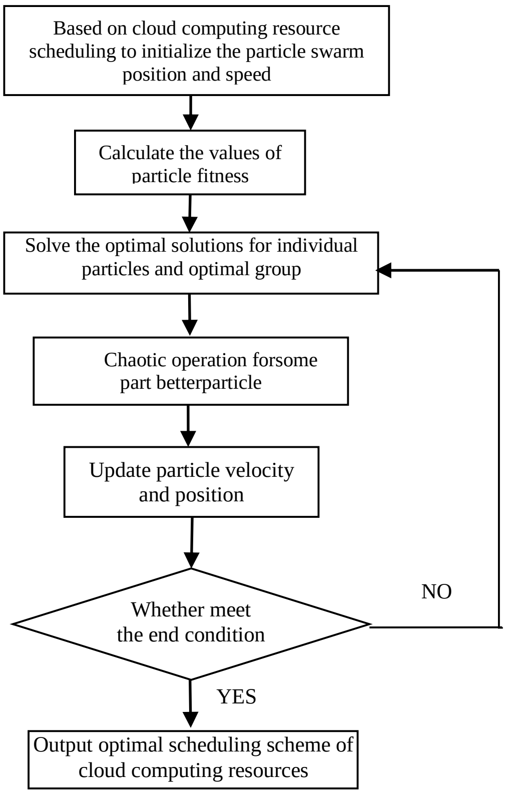

FIGURE 1 CMP task scheduling process of CPSO

1) According to the cloud computing system resources to initialize the particle swarm, the initial position and velocity respectively are: $v_{ai} = (v_{a1}, v_{a2}, \dots, v_{am})$, $x_{ai} = (x_{a1}, x_{a2}, \dots, x_{am})$.

2) According to the Equation (8) to calculate the fitness of each particle value, and choose the optimal particle as personal optimal solution P_{best} and group optimal solution g_{best}.

3) To determine whether the particle swarm appear the precocious phenomena. If there is a precocious phenomenon, the following step is to operate the chaotic conditions, the following step is to decode the position of the optimal particle in the group to get the Cloud computing resources optimal scheduling scheme, if do not meet the conditions, continue the iteration.

4 Simulation study

4.1 SIMULATION ENVIRONMENT

To test the validity of the cloud computing resource scheduling model based on CPSO, Gridsim software is used to simulate the local domain of a cloud computing. In order to measure the scheduling scheme of CPSO, using genetic algorithm (GA), the basic particle swarm optimization (PSO) as contrast model. To set the parameter of GA as: population size is 20, crossover and mutation probability were respectively 0.7 and 0.05; to set the parameter of PSO as: the size of particle swarm size is 20, $c1 = c2 = 2$; to set parameter of CPSO as: $\alpha = 0.5$, other PSO is the same.

4.2 DISTRIBUTION OF CLOUD COMPUTING RESOURCE

In Cloud computing system the scope of CPU is [200 2000], the scope of memory scope is [10 1500], the scope of bandwidth scope is [5 200], randomly to generate 1000 physical resources and then virtualize them to guarantee the complexity of physical resource and the diversity of virtual task in cloud environment, part of virtual and physical resources after the abstraction of cloud computing environment as shown in Table 1.

TABLE 1 Virtual and physical resource after the abstraction

Physical resource			Virtual resource		
Memory	CPU	Band	Memory	CPU	Band
200	200	20	300	1000	100
400	500	10	200	2000	60
1500	1000	60	1000	700	40
100	50	5	800	600	20
10	60	30	1500	200	10

4.3 RESULTS AND ANALYSIS

To Run 100 times for each model, then to take the average as the final result of the algorithm. The balance of the CPU, memory and bandwidth for the three kinds of model is shown in Figures 2-4.

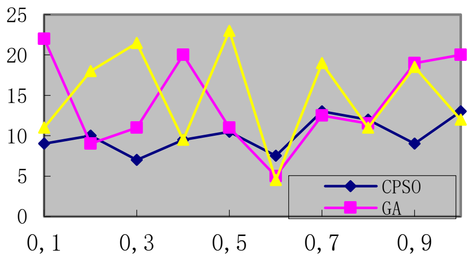

FIGURE 2 The change relation between the equilibrium degree and resources

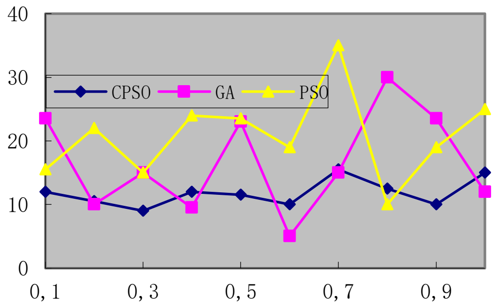

FIGURE 3 The change relationship between memory balancing degree and resources

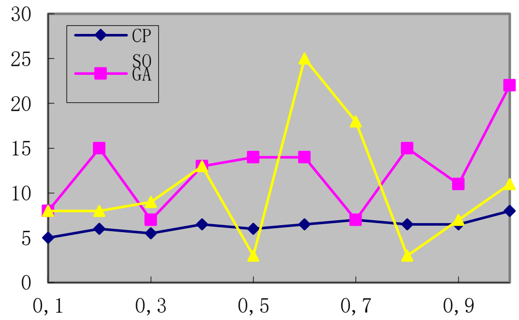

FIGURE 4 The change relationship between bandwidth balancing degree and resources

To analyse and compare the results of three scheduling model in Figures 2-4, we can obtain the following results:

1) In all models, the average performance of CPSO is the optimal; the performance of GA is the worst; it shows that CPSO can well reflect the large-scale cloud computing resources, sharing and dynamic characteristics, also can well decompose task and distribute it on computing resources, so CPSO is a kind of effective computing resource scheduling model.

2) CPSO is very stable relative to the particle swarm optimization (PSO), it can obtain better cloud computing resource scheduling scheme, this is mainly due to the CPSO introducing chaos mechanism, using the advantages of ergodicity and randomness of chaotic motion, ensures the diversity of particles and prevent the phenomenon of search in the late fall into local optimum, which suggesting that CPSO is effective for the improvement of the particle swarm optimization algorithm, and it further improves the convergence of algorithm c and enhances the Resource utilization of cloud computing.

5 Conclusion

According to the characteristics of cloud computing resources scheduling, this paper puts forward a kind of resource scheduling model based on chaotic particle swarm optimization (pso) algorithm, and the performance of the model is verified by simulation. The experimental results show that the CPSO can complete resource scheduling very well in cloud computing environment and has strong practical application value.

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