Research on a Resource Allocation Algorithm Based on Energy Conservation

Jiang Dong-han
Naval University of Engineering
Wuhan, China
18515784386, 430033
e-mail: 457176001@qq.com

Lin Hai-tao
Naval University of Engineering
Wuhan, China
18971337806, 430033
e-mail: Figue2015@163.com

***Abstract*—In this paper, an ICS algorithm based on energy conservation awareness is proposed for resource allocation in cloud computing environment. Firstly, the cuckoo search algorithm is applied to the resource allocation, and the objective function and the fitness function are constructed based on the energy consumption and the performance index. Secondly, the simulation experiment was carried out using Cloudsim, and compared with the first adaptive approximation algorithm. Finally, it is found that compared with other algorithms, the energy consumption of ICS algorithm proposed in this paper is about 11.6%.**

Keywords-cuckoo search algorithm; resource allocation; cloud computing; Cloudsim

I. INTRODUCTION

Cloud computing is a model that allows users to access shared computing pools as needed [1]. Cloud clients can obtain their respective services from cloud service providers. With the proliferation of mobile devices and bandwidth, the client can perform more and more tasks. In order to cope with the growing demand, such as Amazon, Google, Huawei and other large companies have established a large cloud computing platform. The scale of cloud computing platform and the heterogeneity of resources, making the allocation of resources as a challenging task.

The purpose of the resource allocation method is to find resources that satisfy the resource requirements of a given virtual machine without affecting its performance. In general, the resource allocation method is system-centric or user-centric. The former method is traditional, emphasizing the overall system performance improvement such use. While the latter focus on providing end-user quality of tasks. In this paper, we propose a new resource allocation method to improve the utilization rate of resources to improve the energy efficiency of cloud infrastructure. Idle resources consume up to 70% of the power consumed by all utilization [2]. In addition, most data centers have an average resource utilization of about 15-20% [3], which results in a significant waste of energy. Therefore, a resource allocation technique is needed to improve the use of resources. In this paper, the cuckoo search algorithm is applied to the allocation of resources in order to improve the resource utilization rate and improve the energy efficiency of the cloud infrastructure. Using Cloudsim software for simulation evaluation, the results show that energy consumption is about 11.6% less than other algorithms.

II. RELATED WORK

In the existing research, the physical link hardware equipment in the cloud network is measured and comprehensively summarized, including the CPU, disk array and network routing of the current service node, and the data is calculated by the map reduction method. This basis is derived from the initial use of cloud energy efficiency.Paper [4] proposed an energy efficiency model and its measurement method in the cloud computing environment, which can strictly calculate the computer energy efficiency of the single machine and the cloud environment. The result is very close to the measured value, but the energy efficiency model only considers the task of the CPU But does not take into account the energy efficiency of storage and ancillary equipment such as networks, and requires a large number of CPU monitoring agents, but also do not have the necessary consideration for energy efficiency in heterogeneous environments. Jayant et al. [5] conducted a detailed measurement and statistics on the energy consumption and conversion of data transmission and conversion in public and private clouds, and served as a service, storage as a service, platform as a service Consumption of the situation carried out a full range of research and research, but also through the computer, router, data center energy consumption of a detailed analysis of the three types of service energy consumption situation. But did not give a specific algorithm to reduce the energy generated in cloud computing. In [6], a cloud computing simulation environment with multiple data centers is constructed, and the energy consumption of data centers such as servers, transformations, connections and transmissions is designed through the actual distribution of workloads. Such as voltage, frequency, dynamic switch applied to the calculation and the impact of the network. Paper [7] through the depth of hardware, operating systems, virtual machines, data center research, detailed analysis of the relationship between high power and cloud computing energy consumption, the advanced part of the professional analysis, and the future energy efficiency of the forward-looking Sexual discussion [7]. Paper [8] reviewed the current computer hardware and network equipment on the use of energy consumption methods and technology, the current method of the field of a comprehensive study, and distinguish between the cloud computing can be used in energy technology. Most of the above documents are only the summary of the cloud network and review the nature of the study, but did not mention the specific energy consumption algorithm expression, as well as the future energy consumption model, and thus the relevant research efforts are still slightly inadequate.

III. Problem Description

A. Problem Description

Resource allocation is the process of assigning the required computing resources to the tasks that end users employ. Typically, the task is provided by the virtual machine (VM), the virtual machine's resource requirements. Physical server resource capacity. Multiple VMs can be executed in a single PM by using a virtual machine monitor (VMM) such as KVM or VMWare [9]. The proposed resource allocation method (hereinafter abbreviated as ICS) is intended to increase the use of resources without affecting the performance delivered to end-user tasks.

Figure 1 shows the resource allocation framework.

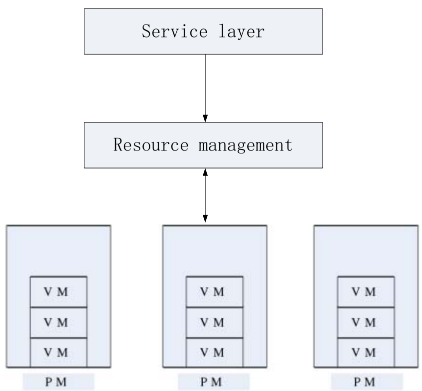

Figure 1. The resource allocation framework

For practical problems, this paper makes the following assumptions:

(1) Each task is independent of each other and has different computing resource requirements, such as CPU, memory and bandwidth.

(2) allows the task to allocate less CPU and bandwidth than the required resources at the expense of performance.

(3) Idle server can enter sleep mode to save energy.

(4) The energy consumption of switching the server from active mode to sleep mode and switching from sleep mode to active mode is negligible.

B. Objective Function

Research shows that static power consumption is due to leakage current consumption of large amounts of energy, can be idle resources to sleep mode to reduce the static power consumption. Dynamic power consumption is due to circuit activity, which depends on resource utilization. While the utilization of resources is largely dependent on CPU utilization. So the power consumption of a certain time by the formula (1) given:

$$P(u) = P_{empty} + (P_{\max} - P_{empty})u(t) \tag{1}$$

Among them, the power consumption when the resource is idle, is 100% utilization under the power consumption for CPU utilization. The study shows that when the resource is idle, the power consumed is about 70% of the power consumed at full load [10]. However, the high utilization of resources can also lead to performance degradation, because the task on which to run does not get enough resources. Therefore, the resources should not be run at too low or very high utilization rates. In order to determine when and which resources should be migrated, we introduce a double threshold strategy. The basic idea is to set the upper and lower limits of utilization threshold, specifically in the 3-5 section to describe. In the experiment, for the modern server, CPU utilization is 100% when the full load power consumption is generally 250W, CPU utilization is 0%, the power consumption is 175W [10].

As the CPU utilization over time, so the actual consumption of the total power for a period of time points, expressed as:

$$E(u) = \int_{t_1}^{t_2} P(u(t))dt \tag{2}$$

The objective function is the minimum value of the energy consumed:

$$MinE(u) \tag{3}$$

C. Fitness Function

The resource allocation method ICS proposed in this paper allows you to group tasks by small amounts of resources, so you can turn off unused resources. The ICS approach considers performance and energy consumption when allocating resources for a task. Evaluate the applicability of resource p to task q from the fitness function, as shown in equation (4):

$$f = \frac{\left(\frac{q_{\text{demand}}}{p_{\text{ability}}}\right)^{a}}{\left(\sum_{i \in q} S_{i,p}\right)^{1-a}} \tag{4}$$

Among them, the available processing capability of resource p is the processing requirement of task q, giving performance affinity, and when it is greater than 1, better performance can be obtained. Is the processing power required to allocate to task i on resource p. A Used to control the weight between performance and energy (). If a is set to 1, only the performance is considered when allocating resources. However, if a is set to 0, only the energy consumption is considered.

IV. ICS Algorithm Design

A. Basic Principles of Cuckoo Search Algorithm

The Cuckoo Search (CS) algorithm is a meta-heuristic algorithm developed by Xin-She Yang and Suash Deb in 2009 [11], which is based on the parasitic behavior of the cuckoo nest to solve the optimization problem. On the one hand, cuckoo (host bird) is randomly selected to lay eggs in the nest of other bird's nest owners (host birds). On the other hand, once the host bird finds a foreign egg, the bird is thrown or the nest is discarded. The original bird's nest in the egg that the original solution, cuckoo eggs that new solution, the whole process means that with a new better solution to replace the original solution. The cuckoo breeding process is simplified by three idealized rules:

(1) Each cuckoo produces only one egg at a time and places it randomly in the nest;

(2) good fitness of high quality bird nest will be passed to the next generation;

(3) the owner of the nest can find the probability of foreign eggs. These birds will be replaced by a new nest, the formula expressed as:

$$N_{new} = n \times Pa \tag{5}$$

where n is the number of the bird's nest, indicating the number of replaced by the new bird's nest. Here, the new nest represents a new random solution,

Under these conditions, the cuckoo birds randomly selected the bird's nest through the Levy flight method. Levi's flight is a random walk from the Levy distribution. The reason for using Levy flight for resource selection is:

(1) Levy distribution has infinite mean and variance, so Levi flight can effectively explore the search space;

(2) Levy flight is a random process, that is, the next state depends only on the previous state;

(3) Levi's flight has scale invariance and is therefore used to simulate clustering problems.

Which is expressed as a random equation:

$$x_i^{t+1} = x_i^{(t)} + \alpha \otimes L(\lambda) \tag{6}$$

Here, and respectively represent the resources at time t and t + 1. Is the step size of the scaling factor, which is the random search vector of Levi's flight. Obviously, if the step grows, then the next solution will be far from the current solution.

B. *Application of Cuckoo Search Resource Allocation Algorithm*

In the proposed resource allocation method ICS, it is assumed that the task is an egg, and the resource is considered to be the nest of the host bird. Suppose each task has some requirements attributes, such as CPU, memory, and network bandwidth. The tasks need to be mapped to resources, and each resource has some processing speed, memory, and network bandwidth, respectively. Our goal is to allocate resources to the task in this way to reduce overall energy consumption without compromising the performance of the task.

The ICS algorithm first uses the Levy flight (Equation (6)) to select the resource from the search space, and the selected resource represents a pilot solution to the resource allocation problem. Our goal is to find the best solution to minimize the energy consumption while meeting the requirements of the task. So, then randomly select the second resource from the search space. Among the two resources selected, resources with smaller power consumption are considered to be better.

Then, some of the resources with utilization rates greater than the high threshold HT are removed from the population and an equal number of new resources are added to the population. The resources removed from the population are no longer used for resource allocation in subsequent iterations. Resources that are removed from the population can be added to the group when their utilization is below the low threshold. The initial population is a set of suitable n resources in which resources are discovered to allocate resources to the task. The total number of resources used is variable and varies with the number of tasks and their resource requirements. The resource allocation algorithm for using the cuckoo search is as follows:

TABLE I. ALGORITHM STEPS

Input: population size n, maximum number of iterations m, task list S_j Output: the best solution for resource allocation
Step1: Initialize the relevant parameters. Define the fitness function and the objective function, randomly generate the initial population of number n, set the maximum iteration and task list; Step2: Use the Levy flight (Equation (1)) to select the resource i from the search space Step3: randomly selected resources from the search space of n resources j; Step 4: Use formula (4) to calculate the fitness f_i of task q for resource i, use formula (4) to calculate the fitness f_j of task q for resource j; if f_i > f_j, resource i is considered better than resource j; Step5: Remove all of these resources from the search space with a utilization rate higher than the upper limit of utilization (high threshold) and add a resource equal to the number of deleted resources to the search space; Step6: Arrange the solution and find the best solution at the moment; Step7: Repeat steps 3 to 6 until the maximum iteration or the optimal solution does not change; Step8: Output the best solution.

V. SIMULATION ANALYSIS

The proposed method is implemented in Cloudsim. Cloudsim is a platform for modeling and simulating cloud computing infrastructures and tasks. For the performance analysis, the ICS algorithm in this paper is compared with the GGA algorithm in [6]. The specifications of the four types of resources that are simulated using Cloudsim's Power Host class are shown in Table 1. The power models corresponding to these servers available in Cloudsim are used to assess energy consumption. For the purpose of comparative analysis, the use of tasks with different resource requirements for testing, resource types shown in Table 1. The simulation is repeated 25 times and the parameters are shown in Table 2.

TABLE II. RESOURCE TYPE TABLE

Demand / Types	CPU （ mips ）	Number of cores	RAM （GB）	Storage （GB）	Bandwidth(gbps)
Resouce 1	2900	4	6	500	10
Resouce 2	3100	4	6	500	10
Resouce 3	2900	8	10	500	10
Resouce 4	3100	8	10	500	10

TABLE III. PARAMETER SETTINGS TABLE

Number of tasks	5-40
High threshold (HT)	0.9
Low threshold (LT)	0.2

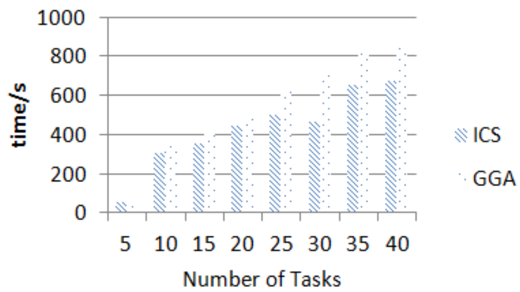

Figure 2. Number of tasks VS time.

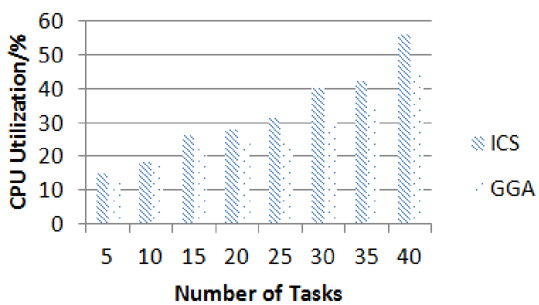

Figure 3. Number of Tasks VS CPU Utilization.

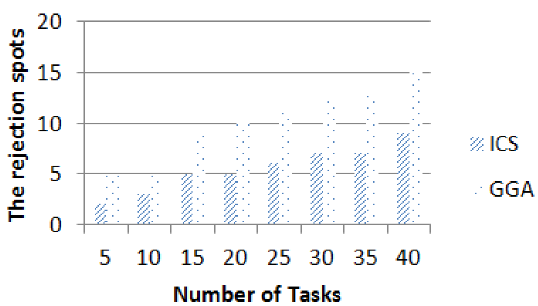

Figure 4. Comparison of rejection numbers.

Figure 2 depicts the GGA algorithm and ICS algorithm to meet the required number of tasks required to run time. The ICS algorithm time is significantly less than the running time of the GGA algorithm when the number of visible times increases as the number of tasks increases and the number of tasks is equal.

Figure 3 depicts the CPU utilization comparison between the GGA algorithm and the ICS algorithm. Compared with the GGA algorithm, ICS algorithm has higher CPU utilization. Therefore, ICS algorithm is more energy efficient and environmentally friendly.

Figure 4 depicts the comparison of the number of rejected tasks for the two algorithms as the number of tasks increases. This is because the task is rejected when the number of resources does not meet the task execution requirements. Obviously, the ICS algorithm observes less task rejection than the GGA algorithm.

VI. CONCLUSION

This paper presents an ICS approach to improve energy efficiency and optimizes resource allocation based on cuckoo search. The proposed ICS resource allocation method is implemented in Cloudsim and is tested using tasks with different resource requirements. The results show that energy consumption is saved by 11.6%. Next, we can extend the proposed resource allocation method by identifying the dependencies between tasks.

REFERENCES

[1] Coutinho E F, Sousa F R D C, Rego P A L, et al. Elasticity in cloud computing: a survey[J]. Annals of Telecommunications, 2015, 70(7):289-309.

[2] Azmy N M, El-Maddah I A M, Mohamed H K. Adaptive Power Panel of Cloud Computing Controlling Cloud Power Consumption[C]// Africa and Middle East Conference on Software Engineering. ACM, 2016:9-14.

[3] Beloglazov A, Abawajy J, Buyya R. Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing[J]. Future Generation Computer Systems, 2012, 28(5):755-768.

[4] CUFF J A, BARTON G J. Application of multiple sequence alignment profiles to improve protein secondary structure prediction[J]. Proteins－Structure Function and Bioinformatics, 2000, 40(3):502－511.

[5] JAYANT, ROBERT B W. Green cloud computing: balancing energy in processing, Storage and Transport[J]. Proceedings of the IEEE, 2011, 99(1):149－167.

[6] Zhang K. A generational genetic algorithm with dynamic population size[C]. Southeast Regional Conference, 2009, Clemson, South Carolina, Usa, March. DBLP, 2009:58.

[7] HUA S, SUN Z. A novel method of protein secondary structure prediction with high segment overlap measure:support vector machine approach[J]. J Mol Biol, 2001, 308(2):397－407.

[8] KIM H, PARK H. Protein secondary structure prediction based on an improved support vector machines approach[J]. Protein Engineer, 2003, 16(8):553－560.

[9] Liu Peng . Cloud computing [M]. Beijing: Electronic Industry Press .2015.

[10] Yang X S. Cuckoo Search[M]// Nature-Inspired Optimization Algorithms. 2014.

[11] Alahmadi A, Alnowiser A, Zhu M M, et al. Enhanced First-Fit Decreasing Algorithm for Energy-Aware Job Scheduling in Cloud[C]// International Conference on Computational Science and Computational Intelligence. IEEE, 2014:69-74.