Research on Data Center Energy Saving Algorithm in Cloud Computing System

Yamei Zhang

Xi’an Peihua University, Xi'an 710125, China

312413420@qq.com

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Abstract: Summary With the continuous development and improvement of cloud computing technology, it has been widely used by different operators due to its unique advantages and huge commercial value. However, there are still many shortcomings in system maintenance and management, and the efficiency of energy consumption. It is one of the priorities that need to be addressed. This paper studies the high energy consumption of cloud computing data centers, categorizes the current energy-saving algorithms, and focuses on virtualization-based energy-saving algorithms, DVFS-based energy-saving algorithms, host-based power-off algorithms based on host shutdown/on, and virtual machine migration algorithms. And the energy consumption assessment model of virtual machine migration, and the advantages and disadvantages of the algorithm are briefly explained.

1. Introduction

Cloud computing is the mainstream technology of today's Internet. Cloud data center is the core of cloud computing. The scale of its servers and supporting equipment is growing rapidly with the continuous expansion of data centers. In order to improve the user experience, it is necessary to provide high quality and stable service quality, and to respond quickly, and the rapid response is based on the coordinated and efficient operation of massive servers. Massive servers obviously consume huge amounts of energy in the normal operation of cloud data centers. If cloud data centers have high energy consumption and low resource utilization levels, the operating costs of cloud service providers will increase, so the data is growing in size. The central energy consumption of electricity and other issues has attracted widespread attention. At present, China's data center energy consumption is relatively high, data center energy conservation level is relatively low, energy conservation has a large optimization space, and is also an important effort in China's energy conservation and emission reduction [1].

2. Data Center Energy Distribution

Cloud computing data centers are built on massive servers. Massive servers are connected through network devices and are cooled during operation to avoid excessive temperatures. The solid cloud computing data center is mainly composed of IT equipment, power distribution system, cooling system, and network connection equipment. The energy consumption of the data center is dynamically changed during the operation due to the number of users requesting cloud services, but the energy consumption of various facilities in the data center is distributed according to a certain proportion. As shown in Figure 1, according to research by the Lawrence Berkeley National Laboratory (LBNL) in the United States, the energy consumption in the data center is roughly distributed: 46% for IT equipment, 31% for refrigeration systems, 8% for UPS, and 4% for lighting, other energy consumption accounted for 11% [2]. At present, experts and scholars in various countries have optimized energy consumption in data centers in various aspects according to the energy consumption distribution of data centers. Among them, due to the current low utilization rate of data centers, how to improve the utilization rate of IT equipment to achieve energy saving and emission reduction has become a research hotspot of energy saving and emission reduction. IT equipment is mainly composed of servers, storage devices, and communication devices. Among them, server energy consumption accounts for about 80% of IT equipment energy consumption, and storage equipment and network communication equipment consume about 10% of IT equipment energy consumption. It can be seen that the energy saving and emission reduction of servers will be the focus and difficulty of energy saving and emission reduction of IT equipment. So, let's explore the energy distribution of a single server. Server energy consumption map as shown in Figure 1.

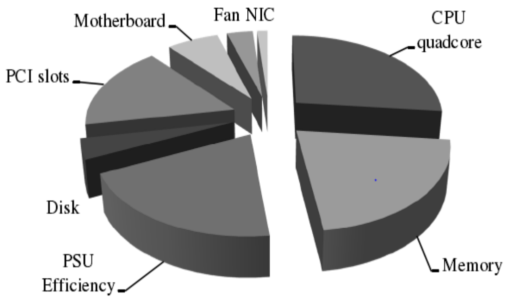

Fig. 1.

Fig 1. Server energy consumption map

3. Virtual Machine Energy Consumption Assessment Model

According to the experimental results of Intel Labs testing the energy distribution of a single server, the energy consumption of a single server in the data center is CPU, memory, power supply loss, PCI slot, motherboard, hard disk, fan and network card NIC. This paper mainly considers CPU utilization and RAM utilization when building a virtual machine energy consumption assessment model [3]. At the same time, this paper considers the cost problem in the virtual machine process when constructing the virtual machine energy consumption evaluation model, and introduces the penalty energy consumption, which is expressed as Epunish. In the simulation experiment of Cloud Sim3.0, because the cost of the virtual machine in the migration process is different, this paper also assumes that the penalty energy consumption has the Poisson distribution. In addition, the energy consumption of the virtual machine for a certain period of time should be proportional to its host. In summary, this paper mainly considers CPU power consumption, memory energy consumption and penalty energy consumption for virtual machine energy consumption assessment. the specific calculation formula is as follows:

The calculation formula of CPU energy consumption of virtual machine A is

$$E_{cpu-\text{A}} = \alpha_{cpu}\mu_{cpu-A} + \kappa_{cpu}\gamma_{cpu} \tag{1}$$

Where κ_cpu and γ_cpu are constants, the processing unit refers to the size of the processing unit mips available to virtual machine A, and total_mips refers to the mips size of the processing unit of the host host of virtual machine A. M_(cpu-A) is the CPU utilization of virtual machine A[4].

The calculation formula for the RAM energy consumption of virtual machine A is:

$$E_{RAM.\text{A}} = \alpha_{RAM}\mu_{RAM} + \kappa_{RAM}\gamma_{RAM} \tag{2}$$

α_{RAM} and μ_{RAM} is a constant, URAM is the RAM utilization of virtual machine A.

The virtual machine penalty energy consumption calculation formula is:

$$E_{puhA} = \beta_{puh}P(\lambda) \tag{3}$$

Where k=1, βpuh is a penalty constant, and P(λ) is a Poisson distribution probability. λ is the average number of violations of the Service Level Agreement (SLA).

In summary, the energy consumption assessment model of virtual machine A is:

$$E_A = E_{cpuA} + E_{RAMA} + E_{puhA} \tag{4}$$

In addition, the paper also gives the calculation method of the fitness of the virtual machine segment between virtual machines A and B in the virtual machine queue. The calculation formula is:

$$F_{AF} = \frac{(E_A+E_B)}{2} \Big/ E_{max} \tag{5}$$

EA and EB are the energy consumption assessments of virtual machines A and B respectively, and Emax represents the larger energy consumption of virtual machines A and B.

4. Cloud Data Center and Energy Saving Technology Overview

As an emerging computing model, cloud computing has developed extremely fast, providing users with flexible behaviors and QoS services that users can pay as they go. According to its characteristics, it can be defined as an Internet-based computing method. In this way, Internet-related IT capabilities can be embedded into service functions by providing services for users to use. In this way, users are not When you understand the details of the cloud service, you can use it. Users do not need to have the corresponding professional knowledge, and do not need to learn the detailed operation capabilities of each device. Ultra-large-scale cloud computing can not only achieve virtualization, but also share relevant data highly. It can be expanded according to usage requirements, and cloud computing can reliably store massive amounts of data at a lower price. The problem of energy consumption in cloud computing is an urgent problem to be solved in the development of cloud computing. At present, the energy-saving mechanism of cloud computing is divided into two types according to different power management: dynamic and static power management technologies; according to different energy-saving stages, it can be divided into three categories: virtual machine technology, dynamic voltage. frequency adjustment technology [5].

5. Virtualization-Based Energy-Saving Algorithm

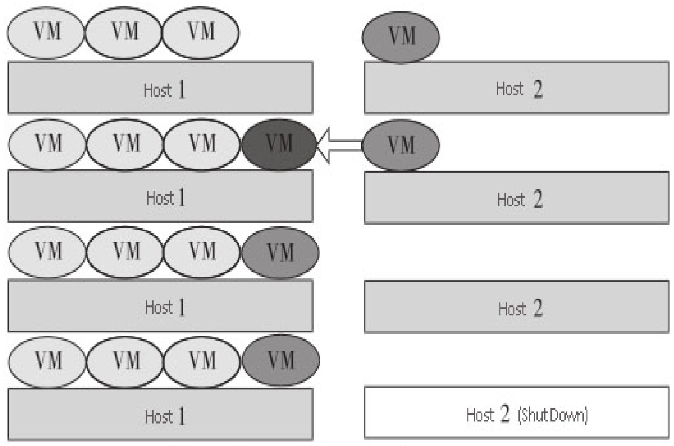

Fig 2. Energy-saving algorithm based on virtual machine migration

By rationally allocating resources, virtualization technology can reduce power consumption and improve resource utilization. In cloud computing, virtualization technology is one of the key technologies. Creating multiple virtual machines is easy to operate and can be completed on the same host, which greatly reduces the number of hardware resources used, and thus greatly improves resource utilization. In the application operation of sharing the same computing node, virtualization can achieve the isolation of the performance of different users; the virtual machine can be migrated between different nodes, which can be realized by using the dynamic migration technology or by the offline migration technology. Dynamic load consolidation needs to be based on virtual machine real-time redistribution. By optimizing the number of nodes, virtual machines are merged into a minimum number of physical nodes, thereby converting unused nodes into energy-saving mode [6]. Virtualization technology reduces the energy consumption of execution and increases the utilization rate of physical resources, but its shortcomings are also obvious: the complexity of system management is significantly enhanced. Due to the introduction of virtualization technology, resource management will involve two aspects: virtual machine provisioning and virtual machine deployment. The process of allocating resources to application tasks in the form of virtual machines is provided by the virtual machine, which usually corresponds to the service level of the hosted application. Protocol (SLA) related, driven by performance target-driven mechanism, performance target usually selects the average time of task response, described by the amount of work completed in unit time; virtual machine to physical host mapping is mainly deployed by virtual machine Upon completion, the deployment of the virtual machine is driven by the policy of the data center, and the strategy of the data center is related to the resource management cost.

6. Experimental Result

6.1 Experimental Environment

The cloud computing simulator used in this experiment is Cloud Sim3.0, and it is configured in the My Eclipse 9.0 tool. The programming language is in Java language. The construction and experiment of the cloud data center simulation environment is completed on the Lenovo desktop. The hardware configuration and operating system parameters of the desktop are as follows:

Processor (CPU): Intel(R) Core (TM) i7-3770 CPU @ 3.40GHz

RAM: 4.00GB

operating system (OS): Windows 7

System type: 64-bit operating system

6.2 Simulation Experiment Data

This paper selects a 10-day sample data from the Plant Lab cloud computing environment as experimental data. The specific data is shown in TABLE 1.

6.3 Total Energy Consumption in the Data Center

Table 1. Different load characteristics of the Plant Lab data center for 10 days

Date	Number of virtual machines	Average	Standard deviation	Quartile1	Median	Quartile3
2019-03-05	1051	12.31%	17.06%	2%	6%	15%
2019-03-09	897	11.44%	16.82%	2%	5%	13%
2019-03-13	1060	10.70%	15.56%	2%	4%	13%
2019-03-19	1516	9.26%	12.76%	2%	5%	12%
2019-03-25	1078	10.54%	14.13%	2%	6%	14%
2019-04-05	1463	12.39%	16.54%	2%	6%	17%
2019-04-10	1357	11.12%	15.05%	2%	6%	15%
2019-04-15	1233	11.56%	15.03%	2%	6%	16%
2019-04-20	1054	11.54%	15.11%	2%	6%	16%
2019-04-26	1033	10.45%	15.19%	2%	4%	25%

The total energy consumption of the data center represents the energy consumption generated during the operation of the cloud data center throughout the day. Total energy consumption is the most fundamental evaluation indicator for energy conservation strategies. Only when the total energy consumption is reduced can the effectiveness of the energy conservation strategy be proved. Because this article did not involve the application of hardware energy-saving strategies in the data center during the simulation experiment of Cloud Sim3.0. Therefore, the change of total energy consumption during the simulation experiment is attributed to the software energy-saving strategy, which is the virtual machine integration strategy used in the simulation experiment. Under the premise of guaranteeing service level agreement (SLAV), the lower the total energy consumption, the better the energy saving effect of the virtual machine integrated energy-saving algorithm [10].

7. Summary and Outlook

This paper introduces cloud computing related content and energy-saving algorithms in cloud data centers, and classifies and analyzes the commonly used algorithms. It introduces single-threshold algorithm and double-threshold algorithm in virtual machine migration algorithm, and establishes virtual machine migration. Time energy model. Different application environments use different algorithms, each with its own advantages and disadvantages. The existing algorithms still have a lot of optimization space. Based on the existing energy-saving algorithms, in the real cloud computing system, how to determine and determine the operating state of the physical host according to different task types and arrival rates, and combine existing energy-saving technologies. Optimize the energy consumption of the system; how to complete the energy optimization goal of the cloud system while meeting certain QoS requirements, these will still be the data center energy-saving algorithms under the cloud computing system, and need further research and solve the problem.

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