Energy Consumption of IT System in Cloud Data Center: Architecture, Factors and Prediction

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Abstract. In recent years, as cloud data center has grown constantly in size and quantity, the energy consumption of cloud data center has increased dramatically. Therefore, it is of great significance to study the energy-saving issues of cloud data centers in depth. Therefore, this paper analyzes the architecture of energy consumption of IT system in cloud data centers and proposes a new framework for collecting energy consumption. Based on this framework, the factors affecting energy consumption are studied, and various parameters closely related to energy consumption are selected. Finally, the RBF neural network is used to model and predict the energy consumption of the cloud data centers, which is aim to prove the accuracy of the framework for collecting energy consumption and influencing factors. The experimental results show that these parameters under the framework for collecting energy consumption have better accuracy and adaptability to the prediction of energy consumption in cloud data centers than the previous model of energy consumption prediction.

Keywords: Cloud computing · Cloud data center · Energy consumption · Prediction · Architecture

1 Introduction

In recent years, cloud data centers are facing more and more traffic demands, resulting in the continuous formation and expansion of cloud data centers around the world [1]. Although their economic profits are increasing, huge energy consumption has also received more and more attention. Since cloud computing can

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realize the flexibility and scalability of computing resources [2], and the sheer size of its scale, the problem about energy consumption of cloud data centers has changed from decentralized way in the past to the current centralized approach [3,4]. In order to optimize the use of energy consumption in cloud data centers, it is necessary to establish a high-precision prediction model of energy consumption for cloud data centers.

In view of the above situation, the RBF neural network is used to model and predict the energy consumption of the cloud data centers, which is aim to prove the accuracy of the framework for collecting energy consumption and influencing factors.

2 Architecture

The framework for collecting energy consumption of IT system proposed in this paper is extended on the basis of the framework for collecting energy consumption of IT system proposed by Zhao, Z. [5] in 2016, and is improved in the details. Figure 1 is the framework for collecting energy consumption of IT system.

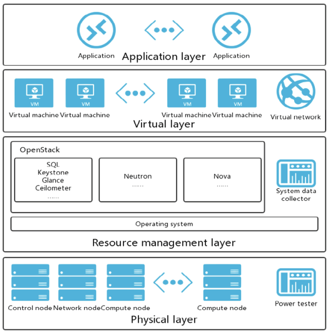


Fig. 1. The framework for collecting energy consumption of IT system

The framework can be divided into physical layer, resource management layer, virtual layer and application layer. The physical layer is located at the bottom of the framework of cloud environment and is divided into physical resources for building cloud environments and power tester. The physical resources used to build the cloud environment is the infrastructure built by the cloud environment, which are the fundamental source of energy consumption of the IT system, and the main target of cloud data center energy consumption prediction. The resource management layer is located above the physical layer and is divided into the operating system, cloud computing resource management service and system data collector. The virtual layer is the third layer of the framework of cloud environment and is to provide users with virtualization platforms and virtualized resources. The application layer is located above the virtual layer and is to run the required application according to different requirements on the virtual machine that the users applies for.

3 Factors Affecting Energy Consumption of IT System

The key innovations presented in this paper are: By decomposing the energy consumption of IT system of the cloud data center and selecting better factors affecting energy consumption to train the RBF neural network, the prediction ability of the RBF neural network model is better than the previous model of energy consumption of IT system, which is aim to prove that these factors play a crucial role in the energy consumption of IT systems.

Modeling energy consumption based on system usage is a usual method of energy modeling. According to the related research [6], the top six system parameters in power consumption of virtual machine have a significant nonlinear relationship with the energy consumption of virtual machine, which are user mode runs using the percentage of total CPU time, core state runs using the percentage of total CPU time, memory utilization, the total amount of I/O transfer per physical device per second, number of pages missing per second of system, and the physical machine load of each physical device. Moreover, because there is a massive scale of the data in the cloud data center, this paper will eliminate the number of pages missing per second of system, which affects the model of energy consumption minimally.

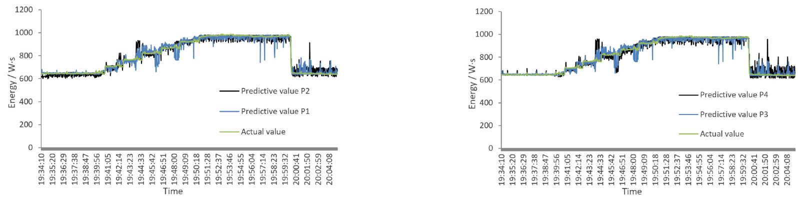
Through experiments, it is found that if the system information is collected for only this part of the equipment, not only can the burden of equipment which collect system information be reduced, but also a predictive model with higher fitting degree can be obtained.

As the experiments showed, we found that the energy consumption of IT systems is extremely sensitive to changes in the energy consumption in a few seconds nearby. Therefore, in the case of maintaining the energy object model with strong objectivity and robustness, and improving the accuracy of the energy consumption model, this paper keeps the modeling method of randomly disturbing the training samples, and adds the energy consumption in the time of last unit to the data set of the training model.

4 Application and Experiments

This paper compared the data from the above experiments from two aspects. On the one hand, we observed the result about whether the training data of the RBF neural network included the compute nodes that enter the virtual layer. On the other hand, we observed the result about whether the training data of the RBF neural network included energy consumption data in the time of last unit.

The data of this experiment were all analyzed using RBF neural network. The same part of the training data included the system information data of the control nodes, the network nodes, and the compute nodes that entered the virtual layer and the energy consumption in the time of last unit. The different parts were that the first training data did not include the compute nodes that did not enter the virtual layer, and the second training data included the compute



(a) With and without the compute nodes that entered the virtual layer.

(b) With and without energy consumption data in the time of last unit.

Fig. 2. The training results of the RBF neural network

Table 1. Error comparison in two cases

Model	P1	P2	P3
The sum of squared errors	38.415	43.827	63.181
The relative error	4.2%	4.8%	6.9%

nodes that did not enter the virtual layer. In Fig. 2(a), the predicted value P1 was the training situation of the training data that did not include the compute nodes that did not enter the virtual layer; the predicted value P2 was the training situation of the training data that included the compute nodes that did not enter the virtual layer.

Although the prediction result of P1 at a few special points was extremely extreme, the predicted value P1 had a better fit with the actual value in comparison with the predicted value P2.

As shown in Table 1, we found that there was better predicted effect of the RBF neural network model, which was trained by the training data that did not include the compute nodes that did not enter the virtual layer. From this experiment, we found that when predicting energy consumption in a cloud environment, it was correct to use the system data of the control nodes, the network nodes, and the compute nodes that entered the virtual layer as the training data.

The data of this experiment were all analyzed using RBF neural network. The same part of the training data included the system information data of the control nodes, the network nodes, and the compute nodes that entered the virtual layer. The different parts were that the first training data included the energy consumption in the time of last unit, and the second training data did not include the energy consumption in the time of last unit. In Fig. 2(b), the predicted value P1 was the training situation of the training data that included the energy consumption in the time of last unit; the predicted value P3 was the training situation of the training data that did not include the energy consumption in the time of last unit.

Although the prediction result of P1 at a few special points was extremely extreme, the predicted value P1 had a better fit with the actual value in comparison with the predicted value P3.

As shown in Table 1, we found that there was better predicted effect of the RBF neural network model, which was trained by the training data that included the energy consumption in the time of last unit. From this experiment, we found that when predicting energy consumption in a cloud environment, it was correct to use the energy consumption in the time of last unit as the part of training data.

5 Conclusion

This paper analyzes the architecture of energy consumption of IT system in cloud data centers and proposes a new framework for collecting energy consumption. Based on this framework, the factors affecting energy consumption are studied, and various parameters closely related to energy consumption are selected.

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