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A Survey about Power Management Techniques for High Performance Data Centers in Cloud Environment

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Abstract

The ultimate goal of energy management is to reduce the rising power dissipation of hardware. Regulating the operating temperature will improve the reliability and stability of the system components. The studies show that various power management models are available, and each of them are trying to improve their efficiency. This paper surveys different power measuring techniques to achieve power management. The most power consuming components in data centers are disk storage, processor, network, I/O controller, memory and so on. Normally the power measuring techniques provide error while measuring the per VM power. This paper describes different type of power consumption reduction model which improve the accuracy and energy efficiency.

Key Words: **Cloud computing, Virtual machine, Performance monitoring counter, Power capping, Power efficiency.**

1.Introduction

Cloud computing is one of the emerging technologies used for sharing resource. The cloud provides services like as resources. The virtualization technology mainly relied on cloud computing environment. Server consolidation and live migration are the two techniques to reduce the energy usage in cloud data centers. The cloud data centers are more attractive because it contains more number of servers and cost of the applications is very less compared to the traditional data centers. The traditional data centers contain huge collection of different applications and multiple software architecture. This gave a mixed hardware environment, application where patching and updating is frequently needed. But the workload is complex. Compared to the traditional data centers the cloud data centers provide much better features. It contains single standard software architecture. The cloud data centers provide a homogenous hardware environment. Here minimal application patching and updating is needed [1].

The increased computational power is a major problem of modern data centers in cloud environment. The data centers contain number of devices and all these devices are available for users at any time. Due to this, the energy consumption of data centers increased rapidly. The increased energy consumption makes some problems like reliability, stability, security, and environmental issues. To solve the problems of energy management, some methods such as energy aware job scheduling mechanism, power off the unused nodes, energy efficient hardware architecture, server consolidation, and virtualization of computing resources are used. So the energy management and control has become a major part in the data centers. Today numbers of power management models are available for control the energy consumption in virtualized data centers. This paper gives an idea about different power models.

2 Power management models

This section describes about different types of power models and scheduling algorithms. Which will helps to achieve better power management in cloud data centers.

2.1Virtual Machine Power Metering and Provisioning

Joulemeter is one of the power metering tool proposed by Kansal et al., which infer power consumption at run time [2]. Here the power management is maintained for virtualized data centers. For VM power calculation the joulemeter tracking all significant hardware resource usage. Finally the resource usage is converted to power usage.

The joulemeter mainly contains three modules. First one is the system resources and power tracing module which reads the disk usage, power usage and CPU utilization of the particular virtual machine. The second one is resource tracing module which uses the resource tracing module to collect the resource usage of each VM. The last one is the base model tracing module. Here the model parameters use different learning technique to collect the power usage information.

There is no additional instrumentation is needed for this mechanism. It also uses online power consumption monitoring system called as micro processor performance counters and it took the benefits of “trickle-down” effect [3]. Joulemeter provides high accuracy and got errors within the range of 0.4W to 2.4W. The joulemeter solve the power capping problem in VM. The major advantages are low run time overhead, high accuracy and reduce power provisioning cost in data centers.

2.2 WattApp: An Application Aware Power Meter for Shared Data Centers

This is an application level power meter proposed by koller et al., which is used in data centers for heterogeneous applications [4]. WattApp provide high accuracy, speed and heterogeneity support. WattApp contains three different flows that are independently executed. The first one is the model builder flow which reads the application and system logs. It will take power and throughput values from the VM for processing each application. The second one is the configuration management flow, which is executed by a configuration orchestrator. The configuration orchestrator refers the application power table and collects the application details and server type.

Normally the calibrations runs are needed in each server for better power management, but it will not change the normal workload. To overcome this problem WattApp introduces a mechanism called as server stealing mechanism. The last flow is oracle flow which is executed by the oracle query interface. To achieve better power management it uses TPC-W, SpecPower, Domino, daxpy, and HPL benchmarks. These benchmark evaluate the features of CPU caches and memory. For implementing this power model it uses VMware hypervisor. This method provides 95% of accuracy and it will reduce the error rate.

2.3 VMeter: Power Modeling for Virtualized Clouds

The live migration can reduce the power consumption of VM but without the help of a system monitoring and analysis tool it may not be predicted. To solve this problem, Bohra et al., propose a low overhead power model called as VMeter [5]. This method provide a utility program to collect the utilization details about CPU, DRAM, cache, and disk values of each VM. For monitoring purpose it will uses the system event files and hardware performance counters.

VMeter includes two components. First one is VM_Monitor, which also contains two tools they are oprofile and iostat. Oprofile is capable of taking power profiling of an entire system. Iostat is a system monitoring tool which will collect and display the operating system storage input and output statistics. Iostat will collect the resource utilization details about CPU cache, DRAM and disk values. The second component of VMeter is VM_power. This will calculate the power readings from different components.

This method based on online monitoring of system resources and their performance. The monitoring components are CPU, disk, DRAM, and cache. The experimental studies show that this model provides almost 93 to 94% of accuracy. The NAS NPB, GCC, BYTEMark and cachebench are the industry standard benchmarks. However it helps to evaluate the power of each VM components. The PowerNap is a method which improves the power conservation efficiency [6]. These power metering tool provide accuracy of 93 to 94%. This is implemented with the help of Xen hypervisor.

2.4 Energy-Based Accounting and Scheduling of Virtual Machines in Cloud System

Kim et al., uses a method called as digital multi meter (DMM) and PXI data acquisition interface to calculate the energy consumption of each virtual machine in a data center [7]. Based on this model Kim et al., propose a scheduling algorithm which is called as energy credit scheduler algorithm (ECS). The goal of energy credit scheduler is to reduce the energy consumption into a lower level than that of the energy budget.

This model is implemented by using Xen hypervisor and uses the SPEC CPU2006 benchmark for evaluation. The energy credit scheduler is a type of fair-share scheduler that allocates processor time to each virtual machine according to their energy credit value and then schedules the VM based on their energy budget instead of processor time credits. The infrastructure cost is very less compared to the other models. It can also provide high energy efficiency with errors less than 5%.

2.5 Energy Efficient Allocation of VM in Cloud Data Centers

The live migration is an important feature of virtualization technology for load balancing, maintenance and energy reduction. Mainly it is used in data centers. The migration of virtual machines itself need more power consumption. For this reason Beloglazov et al., propose live migration technique reduce the power consumption [8]. Live migration of VM provides system management in virtualized data centers. Virtual machine live migration is a process for transferring virtual machine or application from one physical server to another, without disrupting or disconnecting the client or application [9]. The storage, network connections and memory of the VMs are transferred from the original physical server to the other machine. Network speed and bandwidth, VM memory size and memory dirtying rate are effects the migration performance, due to this latency, migration downtime and network traffic is generated [10]. The live migration of virtual machine increases the performance, manageability, fault tolerance and energy efficiency and reducing the total downtime [11].

The server consolidation in live migration is an effective way towards the energy conservation. The objective of the server consolidation is that reduce the power-on systems as low as possible. To achieve this it will automatically turn off the system which is not in use, then only it can reduce the power consumption. This will overcome the energy performance trade-offs. The optimization algorithm improves the scalability and fault tolerance. Due to the high popularity of cloud computing system, the VM migration across data centers will be highly beneficial to the data centers. Migration cost of virtual machines are vary, which depends upon the VM configuration and workload characteristics [10]. This technique is implemented with the help of cloud sim tool kit.

2.6 Fine-Grained Power Management Using Process-Level Profiling

Need for an energy profiling tool Chen et al., introduces fine-grained energy management power profiling tool such as pTopW [12]. Most of the power profiling tool provides component level power information. pTopW generate a group of APIs and collects real time power profiles and make decision based on this information. The characteristics of this tool are that it runs only in the windows platform and runs at kernel level and collect data from different applications and process.

Here additional hardware is not required because it is a software based tool. Due to the lightweight property the operations of pTopW will not affect the performance of other applications. The major components of pTopW are data collector, energy model, and memory data store. In each cycle the data collector will retrieves the state information about components. The system performance counter APIs provide system related data. After collecting the information it will send it to the energy model module. This model converts system state information into energy consumption and power. Finally the result will be stored into the data store.

There are two significant user interfaces supported by pTopW. First one is energy aware application programming interface (API) and the other one is performance counters. The process can invoke these APIs to achieve energy consumption based on energy consuming components. In addition Chen et al., uses a power aware system module which is called as Energy Guard. Most of the power used by the system is wasted because the systems are always in full power mode even it is not being used. So the Energy Guard protects the system from the wastage of energy. Wattch is a framework which monitoring the microprocessor power dissipation [13]. This method is much faster than the existing power measuring tools.

2.7 Virtual Machine Power Measuring Technique with Bounded Error in Cloud Environments

The objective of this paper is fine-grained power management and provides better power efficiency to the virtual machines. For that Xiao et al., introduce a fine-grained power management model called as PMC based power model [14]. This paper talk about the utilization and accuracy of power model and make a comparison between two classes of VM power models. First one is the utilization based VM power model and the other one is PMC based VM power model. Comparatively the PMC based power model is better than the other.

Choosing the correct subset of PMC candidates are the first step, when making a PMC based power model. The PMC candidates include processor, disk, memory, and I/O controller. To achieve these values it uses 401.bzip2, 429.mcf, TPC-W, cachebench, and IOZone benchmarks. It can be implemented by using VMware or Xen hypervisor. Xiao et al., also propose a virtual machine scheduling algorithm which is called as PMC based credit scheduling (CS) algorithm. The CS algorithm schedules the virtual machine based on the CPU utilization. The algorithm helps to find out which VM has less load, and allocate the task to that particular VM. If there is no enough space, then the task will be splitted and given to two VMs. The CS algorithm is effective to improve the power efficiency and accuracy.

3. Comparison Table

The table shows a comparison between different power models based on accuracy, error rate, and efficiency.

Ref .No	Model	Accuracy	Error rate	Efficiency
[1]	Joulemeter	High	Low	High
[2]	WattApp	High	Low	High
[3]	Vmeter	Low	-	High
[4]	Energy Credit Scheduler Algorithm	-	Low	High
[5]	Live migration	High	-	High
[6]	pTopW	-	Low	-
[7]	PMC based VM power model	High	Low	High

4. Conclusion

The energy management is the major challenging issue in data centers. Day by day the processing rate of data is increased. The data centers which provide advanced devices to the users at any time based on their needs. At present so many power consumption models are available. These models are trying to reduce the energy consumption and to overcome the energy performance trade-offs. Different power measuring tools and scheduling strategies are used for reducing the CPU utilization of VMs. This survey describes all these methods and helps to choose a better power model for achieving energy efficiency in modern data centers. By considering all the features, PMC based model and PMC based CS algorithm is better than other power management models.

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