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An Advanced Survey on Research Issues of Energy Management in Cloud Computing

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Abstract*— Cloud computing has revolutionized the information technology industry by enabling elastic on demand provisioning of computing resources. The increase of Cloud computing has resulted in the organization of large-scale data centres around the world contain thousands of total nodes. This paper presents overview of cloud computing, issues in cloud computing, novel techniques, and software for distributed dynamic consolidation of Virtual Machines (VMs) in Cloud data centres. The goal is to improve the utilization of computing resources and reduce energy consumption under workload independent quality of service constraints. Dynamic VM consolidation leverages fine-grained fluctuations in the application workloads and continuously reallocates VMs using live migration to minimize the number of active physical nodes. Energy consumption is reduced by dynamically deactivating and reactivating physical nodes to meet the current resource demand. The proposed approach is distributed, scalable, and efficient in managing the energy-performance trade-off. In this paper, we introduce DVFS concept with live migration technique to improve efficiency of energy management and adaption scheme on real-time services.

Keywords*— Cloud Computing, Data Center, Energy Management, Virtualization, Real-time Service, DVFS, Live Migration

I. INTRODUCTION

Cloud computing is becoming an important opportunities for industry to provide a high degree of scalability and serviceability of computing resources. By definition of cloud and capability to support computing [1] in the different services types such as Iaas Paas or Saas makes cloud computing becomes a favourite computing system today. Computing resources that are available on demand, elimination of an up-front commitment by cloud users and ability to pay per use of computing resources are benefits of cloud computing. These features motivate service providers to increase their resources in data centre [9] to support user demand that is enlarging significantly such as processor unit, storages and etc. Consequently, electrical power is consumed increasingly and becomes a major concern [2].With more and more suppliers began offering cloud computing services, these services are convenient to users but consuming a lot of energy. Thus, how to save the energy of the data centre without affecting both the economic efficiency and system performance is an important issue. Virtualization technology can simulate a variety of different platforms and manage the resources of the system. By applying the virtualization technology, in accordance with the requirements of the users to configure a virtual machine, both the computing environment and resource management problems can be solved.

In cloud computing environment, the amount of workload will affect the loading of the physical machine of cloud server. If in accordance with the appropriate voltage regulation would be effective in improving energy efficiency and reduce the overhead. This paper proposes a mechanism to adjust the system voltage based on the CPU utilization, and migrating tasks in a heavy loaded machine to idle machines [5]. Dynamic CPU allocation with appropriate utilization levels will help service provider to conserve more energy and get better performance. Thus the new technique not only to reduce energy consumption[7] in cloud data center but also to provide better performance by introducing a CPU re-allocation algorithm that combined DVFS concept with live migration technique in three characteristics including Longest Completion Time(LCT), Highest Utilization (HU) and Lowest Utilization (LU).

This paper is prearranged as following. In the Section II describes some Overview of Cloud Computing, Section III Contains research issues and Section IV we focus DVFS technique and Section V presents conclusion.

II. OVERVIEW OF CLOUD COMPUTING

A. Definition

Due to the extraordinary success of internet in last few years, computing resources is now more universally available. And it enables the realization of a new computing concept called Cloud Computing [8]. Cloud Computing environment requires the traditional service provide to have two different ways. These are infrastructure and service providers. Infrastructure providers manage cloud platforms and lease resources according to usage. Service provider rent resources from infrastructure provide to serve the end user. Cloud Computing has attracted the huge companies like Google, Microsoft, and Amazon and considered as a great power in today's Information Technology industry. Business owners are attracted to cloud computing concept because of several features.

These are as follows:
- Lower initial investment
- Easier to manage
- Scalability
- Deploy faster
- Location independent
- Device independent
- Reliability
- Security

B. Related Technologies

Cloud computing classically has Characteristics of all these technologies:
- Grid Computing
- Utility Computing
- Virtualization

An overview of these technologies is given here:

1. Grid Computing

Grid Computing [14] involves a network of computers that are utilized together to gain large supercomputing type computing resources. Using this network of computers large and complex computing operations can be performed. In grid computing these networks of computers may be present in different locations. A famous Grid Computing project is folding @ Home. The project involves utilizing unused computing powers of thousands of computers to perform a complex scientific problem. The goal of the project is "to understand protein folding, unfolding, and related diseases".

2. Virtualization

Virtualization [13] introduces a layer between Hardware and operating system. During the sixties mainframe started supporting many users using virtual machines. These virtual machines simulated behavior of an operating system for each user. VMware launched a product called VMware Workstation in 1999 that allows multiple operating systems to run on personal computers. The virtualization forms the foundation of cloud technology. Using virtualization, users can access servers or storage without knowing specific server or storage details. The virtualization layer will execute user request for computing resources by accessing appropriate resources. Typically server utilization in data centres can be as low as 10%. Virtualization can help in significantly improving server utilization.

3. Utility Computing

Utility Computing defines a "pay-per-use" model for using computing services. In utility computing, billing model of computing resources is similar to how utilities like electricity are traditionally billed. When we procure electricity from a vendor, the initial cost required is minimal. Based upon the usage of electricity, electricity companies bills the customer (typically monthly). In utility computing billing is done using a similar protocol. Various billing models are being explored. A few common ones are:

1. Billing per user count. As an example if an organization of 100 people uses Google's Gmail or Microsoft Live as their internal email system with email residing on servers in the cloud, Google/Microsoft may bill the organization on per user basis.
2. Billing per Gigabyte. If an organization is using Amazon to host their data on the cloud, Amazon may bill the organization on the disk space usage.
3. Billing per hour/day. As an example a user may pay for usage of virtual servers by time utilized in hours.

III. RESEARCH ISSUES

Cloud Computing [8] has been widely practiced by IT industry as well as business enterprises in recent times. But, research on it is still at an immature stage. Many existing issues have not been fully addressed; whereas newer problems are arising due to its extensive usage. In his section, we summarize some of the crucial research issues in cloud computing.

A. Virtual Machine Migration

Some vendors have implemented VM migration in their virtualization solution—a big advantage for application uptime in a data centre. What is VM migration? Consider the case of a server with a hypervisor and several VMs, each running an OS and applications. If you need to bring down the server for maintenance, you have to shut down the software components and restart them after the maintenance window—significantly affecting application availability.VM migration allows you to move an entire VM (with its contained operating system and applications) from one machine to another and continue operation of the VM on the second machine. This advantage is unique to virtualized environments because you can take down physical servers for maintenance with minimal effect on running applications. You can perform this migration after suspending the VM on the source machine, moving its attendant information to the target machine and starting it on the target machine. To lower the downtime, you can perform this migration while the VM is running (hence the name "live migration") and resuming its operation on the target machine after all the state is migrated.

B. Server Consolidation

Server consolidation is an effective approach to maximize resource utilization while minimizing energy consumption in a cloud computing environment. Live VM migration technology is often used to consolidate VMs residing on multiple underutilized servers onto a single server, so that the remaining servers can be set to an energy-saving state. The problem of optimally consolidating servers in a data centre is often formulated as a variant of the vector bin-packing problem, which is an NP-hard optimization problem. Various heuristics have been proposed for this problem [10]. Additionally, dependencies among VMs, such as communication requirements, have also been considered recently.

C. Energy Management

Improving energy efficiency is another major issue in cloud computing. It has been estimated that the cost of powering and cooling accounts for 53% of the total operational expenditure of data centres [11]. In 2006, data centres in the US consumed more than 1.5% of the total energy generated in that year, and the percentage is projected to grow 18% annually [10]. Hence infrastructure providers are under enormous pressure to reduce energy consumption. The goal is not only to cut down energy cost in data centres, but also to meet government regulations and environmental standards. Designing energy-efficient data centres has recently received considerable attention. This problem can be approached from several directions. For example, energy efficient hardware architecture that enables slowing down CPU speeds and turning off partial hardware components has become commonplace Energy aware job scheduling and server consolidation are two other ways to reduce power consumption by turning off unused machines. Recent research has also begun to study energy-efficient network protocols and infrastructures. A key challenge in all the above methods is to achieve a good trade-off between energy savings and application performance. In this respect, few researchers have recently started to investigate coordinated solutions for performance and power management in a dynamic cloud environment.

IV. IMPROVING ENERGY MANAGEMENT ISSUES WITH DVFS MECHANISUM

A. DVFS(Dynamic Voltage Frequency Scaling)

As [4], DVFS technique can be applied by monitoring the CPU utilization. When the workload is heavy, real-time migration can be provided for achieving more effective usage of resources under the user unaware situation. Dynamic voltage frequency scaling is a hardware technology that can dynamically adjust the voltage and frequency of the processor in execution time. By applying DVFS technology, without having to restart the power supply, system voltage and frequency can be adjusted in accordance with the specification of the original CPU design into a different working voltage. While CPU works in lower voltage, the energy consumption can effectively be saved. The power consumption of the CPU is measured by multiplying the voltage square with the system frequency. Where V is the voltage, F is the frequency, and C is the capacitive load of the system. The DVFS is the power saving technology by reducing the voltage supply [12]. The reduction of CPU frequency means that the voltage can also be dropped, though it will result in the degradation of the system performance and lead to prolong the execution time. In addition, the overhead of the voltage adjusting should also be considered.

The purpose of the DVFS is to allow the filth of the execution speed of a task by decreasing the CPU frequency and voltage to reduce the power burning up. This technology is often used in real-time systems.

$$\boldsymbol{P = V^2 \times F \times C}$$

As mentioned above, by applying the DVFS technology, CPU voltage can be lowered, but the execution speed of the task will be reduced. From Equation, we can see that if only reducing the frequency, energy cannot be saved effectively. In the system, C is the capacitive load of the system, only in lowering the frequency and also reducing the voltage, the power consumption can be saved effectively.

As implemented Cloud Sim [2] MIPS and frequency are directly related together. They presented three schemes result in reduce energy consumption, Lowest DVFS, Advanced DVFS and Adaptive DVFS, to allocate appropriate MIPS rate to real-time service[3].

B. MIPS adjustment mechanism

A mechanism by applying Cloud Sim to simulate a large scale cloud data centre for energy saving has been proposed in this chapter. The system consists of three parts: the CPU utilization monitoring, DVFS adjustment, and real-time migration. CPU utilization on each host is monitored in the system. According to the measured CPU utilization, an appropriate process will be performed for saving energy consumption.

$$Vcpui = \frac{VM}{HOST}\frac{MIPSi}{MIPSi} \qquad \text{(Eq. 1)}$$

$$CPUutilization = \frac{\sum_{i=1}^{n} Vcpui}{HOST.MIPSi} \qquad \text{(Eq. 2)}$$

In Cloud Sim [6], MIPS (million instructions per second) are used to present the capacity of the host machine, the capacity of VM, and the workload requested by the user. Each workload will be distributed to VMs on different hosts. VMMIPS is the amount of MIPS required for the VM and Host MIPS presents the amount of MIPS the host can support. The utilization of the virtual CPU of a virtual machine, Vcpu, can be calculated by Eq. 1, and the average utilization of CPUs can be calculated by Eq. 2

To reduce energy consumption, we can lower the frequency but inappropriate frequency assigned to virtual machine may result in performance degradation and missing application deadline. implemented Cloud Sim to show that MIPS and frequency are directly relate presented three schemes result in reduce en Lowest-DVFS, ∂-Advanced-DVFS and Adaptive DVFS, to allocate appropriate MIPS rate to real-time services. Apart from controlling energy consumption by load balancing or voltage adjustment at current executed job, process live migration technique when host is more overload than dynamic threshold of current time.

V. Conclusions

Energy management has become an important issue in computing environments. In this paper we conclude that a dynamic resource management with energy-saving mechanism in the cloud computing environment to reduce the energy consumption. DVFS technique can be applied by monitoring the CPU utilization. When the workload is heavy, real-time migration can be provided for achieving more effective usage of resources under the user unaware situation.

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