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Green Cloud and Reduction of Energy Consumption

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ABSTRACT

By using global application environments, cloud computing based data centers growing every day and this exponentially grows definitely effect on our environment. Researchers that have a commitment to their environment and others which was concerned about the electricity bills came up with a solution which called "Green Cloud". Green cloud data centers based on how consume energy are known as high efficient data centers. In green cloud we try to reduce number of active devices and consume less electricity energy. In green data centers toke an advantage of VM and ability of copying, deleting and moving VMs over the data center and reduce energy consumption. This paper focused on which parts of data centers may change and how researchers found the suitable solution for each component of data centers. Also with all these problems why still the cloud data centers are the best technology for IT businesses.

Keywords: Cloud Computing, Green Computing, Energy Efficiency, Green VM Manager.

1. INTRODUCTION

These days, the cloud data centers are growing every minute and by the growing cloud data center, cloud providers need more electricity for running their devices over the data centers. The data centers we are talking about are like Facebook data centers or Google data centers with numerous devices like servers and network devices. On one hand, this mass use of the cloud, consume more electricity, and it means huge bill amounts. On the other hand, more power needs more producing power. We should consider that, for providing electricity power, on the most cases, global electricity supply companies using fossil fuels or in the worst cases, they use nuclear reactors to provide electricity. In both cases there is an extra pressure on our environment. In each case, there is a vast range of pollution from emissions of carbon dioxide (Co2) to nuclear disasters like Fukushima disaster happened in Japan. The green peace highlighted in their research, if cloud computing industry was a country, it was a fifth country in the world as an electricity consumer after USA, China, Russia and Japan [1]. Thus, by reducing the energy consumption in big data centers, the global electricity suppliers do not need to construct new sites and put more pressure on the environment. So,we use the concept of the green computing in the cloud industry and make the green cloud [2].

The concept which is also called as green computing, which means we need to reduce the number of active physical machines by controlling movement and placement of VMs (Virtual Machines) in physical machines. The VMs

should distribute in an effective fashion that instead of simple distribution to finally reduce overall power consumption of data center [3]. This operation differs from sending physical machines into the idle modes, it goes one step more and it can turn off the physical machines [4].

This paper focused on the whole operation for consolidation over servers when overload exists over servers in virtualized data centers and tried to define whole process, from periodic gathering information on hardware level for decision making, to decision making for consolidation VMs in servers and also type of decision which needed to make for consolidation VMs and reducing energy consumption in servers in hardware level.

2. BACKGROUND

Lewis Curtis in [5] points outs the different metric which can affect the decision making for running different component that consume energy. On the other hand, in software layer, the paper had a survey on different tier of the software tiers in data centers and specifies the level of possible reduction of energy.

Kevin Francis and Peter Richardson in [6] have proposed a new architecture for data centers as green data centers which can reduce the energy consumption. In this paper, researchers focused on the application layer of the data centers and point out most of the data centers have a problem in designing applications.

In [7] J. Liu et al, has a research on the cooling systems in data centers, which are very effective for reducing energy consumption. They are working on cooling management system by using wireless sensor to gather the temperature information about whole data centers. By using this information we can control the temperature of the data centers that reduce the energy consumption.

In these works, the researchers tried to reduce energy consumption in different components of the data centers, but, the still major component of data centers which is servers are not seen in the scene. To reduce energy consumption of data centers effectively the major component for us is the servers and the concept of virtualization. Other researches focus on the level of virtualization concept. There are different techniques which most of these techniques are based on the consolidation of the VMs.

One of these researches is done by A. Beloglazov and R. Buyya [8] which the researchers have proposed a technique based on adaptive utilization thresholds for dynamic consolidation of virtual machines. They claim that their technique is very efficient in different work load and it maintained the level of SLA (the Service Level Agreements) violation in the system at as low as 1%.

In research [9], they introduced the technique which is called as VirtualPower. VirtualPower is an online power management that coordinates different power management policies. Also, they tried to explain consolidation in different level, especially in servers, but they did not explain it completely.

3. WHY CLOUD IS BETTER FOR NATURE

Comparing conventional IT equipment with cloud base devices we can use in companies and IT base enterprises, cloud computing services consume less energy compare to the conventional systems with the same outputs [10]. In one research [10], the researchers show that reducing usage of the conventional

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systems like PCs and non-cloud environments very effective for reducing energy consumption.

4. CLOUD COMPUTING DATA CENTERS

In these days, everyone only talking about the pros of the using cloud computing and medium and large enterprises made the moves from conventional infrastructure to the cloud infrastructure. With growing of this technology, the data centers also growing up and this grows needs more electrical power. In figure 1 growth of the usage of the electricity in past years and the estimation of usage in coming days. It illustrates that the usage of electricity by TWhr (terawatt-hours) and shows that the consumption of electricity raise to 1400 TWhr and it is a huge amount of energy [11]. With the aid of these researches out comings, it is obviously showing the need of green technologies.

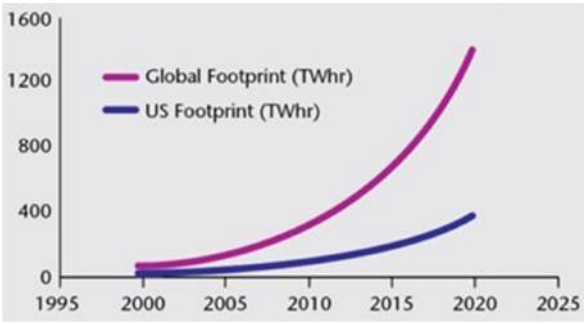

FIGURE 1. Projection of data center electricity use

In another research which shown in following table, as proved in other researches [12], different parts of data centers, have a different usage of the energy. However, it is obvious the physical servers, used more energy and as subsequent it has a more energy cost.

TABLE 1.
Approximately power consumption of different components in data centers [13]

Amortized Cost	Component	Sub-Components
~45%	Servers	CPU, memory, storage systems
~25%	Infrastructure	Power distribution and cooling
~15%	Power draw	Electrical utility costs
~15%	Network	Links, transit, equipment

Thus, the green cloud computing based on all these evidences, targeted the server portion of the data centers and by introducing the green VM manager, tries to reduce the energy consumption and on the other hand, it needed less energy

production. This reduction has a significant effect on nature by reduction of greenhouse gases and also it is important for cloud providers for reducing their costs.

5. DIFFERENT COMPONENTS OF CLOUD COMPUTING DATA CENTERS

Green data centers like other data centers have resources which are the hardware portion of green cloud and the software portion. The architectural model we used in this era is the model designed by Buyya et al [14] in Millburn University worked on it. Based on the layered architecture, there are two different levels which are important for designing the green cloud. First level is resources which are hardware level and another one is software level, which is achieved by controlling the existence and moving virtual machines (VM) over the cloud environment. By study each level of this cloud model, we can easily understand the concept of green cloud. At the first, in system level, which are hardware components present there, we study the present solutions that used for designing green cloud data centers. Then we study the green VM management, which is present in core middleware and need to design new VM manager based on the green cloud concept.

6. GREEN CLOUD COMPUTING IN HARDWARE LEVEL

6.1 PROCESSOR

One of the major parts in data centers, which is important for processing element of data centers and also needs more electricity are the processors. The data centers use dozens, maybe thousands of processors in multi-processors servers. Thus, if we should consider it as major elements of designing the cloud data centers. The previous generation of processor design to have a high performance, but these actions made the processor under the high heat divisions and it made the data centers used the more cooling systems. Fortunately, in these years processor developer designed with high performance and also with high efficiency. They designed a new generation with ability of slowing down the CPU clock speed and using DVS (Dynamic Voltage Scaling) e.g., Intel SpeedStep and AMD PowerNow [15-17]. But still is the researches are going on to find a better solution for designing the efficiency and fast data processing processors.

6.2 PROCESSOR

As a major element of the data centers, servers are the part that we can use the virtualization technology on them. All VMs are created over these servers and make the cloud concept possible. The servers used for the virtualized data center racks is called blade server and they are consuming energy five times more than traditional servers [18]. The virtual machines which are fundamental components of the virtualization technology are staying over these servers and they are enabling multiple OS over the server. The VMs can be run over different physical machines and even sometimes they can move over the data centers which called VM migration. By defining the VM size and moving VM over the

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environment can dynamically configure the system to be more energy efficient. This is one of the advantages of using virtualization concept and using VMs. By combining the DVS methods and VM migration it is reachable to reduce the energy consumption.

6.3 STORAGE

It has been more than a decade the researchers working on the storage systems to reduce the energy consumption. In [19] researchers introduce the technique that called it as write off-loading which is allows data blocks written in one volume, temporary redirect to the active volume in another place in the data center. By this method, they reduced the spanning a disk and by this the energy will be saved. In all these different techniques the goal is reducing the energy consumption and save the energy for active works over cloud data centers.

6.4 COOLING SYSTEMS

The cooling system is about controlling the temperature for increasing efficiency of data centers, but it needed more electricity to run it. Devices in data centers made of metal and metal emit the heat over the devices and it could make device efficiency on the danger line to be failed or effect the device utilization when they are working with high power. Thus, controlling the temperature of server room is vital for the efficiency of data centers [20]. There are different methods for designing rooms which are currently used in data centers. Another option for reducing the energy reduction is choosing the right place for new data centers. To reduce the heating power consumption, big companies like Google and Facebook trying to build a new data centers in cold countries which is most time in a year the outside temperature is around ten Celsius degrees like Finland. In some recent studies, researchers achieve to the solution for optimizing saving energy over cooling system and name it as "PowerTrade" and" SurgeGuard". They express that they saved energy between 23% and 30% by aid of these techniques and different configuration [21].

6.5 NETWORK

The energy data centers using are for different layers switches and devices. There are different methods for saving energy in network infrastructure. One method based on the different energy consumption of different links. For instance, 1Gbps links consume 4 W more than 100 Mbps link and 10 Gbps consume from 10 W to 20 W [22]. On these bases they applied energy saving method to the existing network by changing the link speed dynamically and by changing the speed consuming energy will be less. In another method which called as SLC (Server Load Consolidation), used job scheduling or balancer to consolidate job over few numbers of servers in data centers [23]. This is one method which is very important to us, which make are the way to the green cloud computing.

7. GREEN CLOUD COMPUTING IN SOFTWARE LEVEL

On the traditional method of the cloud VM management is based on the distributed manner and their job is how to manage the VMs to be distributed over the environment. They try to find the inactive physical servers and use those to balanced load over the physical servers. An important aspect of cloud data centers in hardware level is even when servers are idle, they are still consuming energy. In [24] in experimentally and statistically, they obtained the different level of power consumption in different VM managers [25].

As illustrated in the figures 2, there is VM manager and it is responsible for distributing VMs over physical servers. If the system needs another VM, after creation of new VM, based on the fact that it should not be any physical server without a job or in idle mode. The manager which is shown in figure 5 will send the new VM to the Server3. The task of these types of managers is creating an environment that reduces the number of inactive physical servers.

In green cloud VM managers, managing the VMs is different, in this case the part which VM manager needs to find idle physical servers are the same as the pervious, but here, after the detecting idle servers, if it was possible, the turning them off because servers in idle mode still consuming electricity. The action which occurs is illustrated in the following figures. Figure 3.(b) occurs when a new VM created by VM manager.

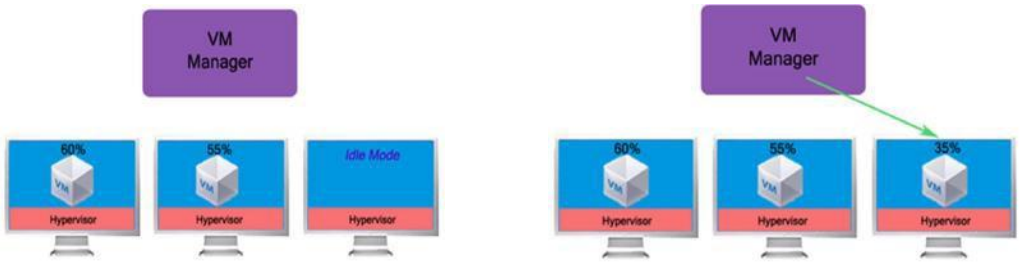

FIGURE 2.
(a)Cloud computing VM manager (b)Distributing VM over cloud computing

FIGURE 3.
(a)Consolidation of new VM (b)VM consolidation

In this procedure, a VM manager needs some information about the data center environment like measuring temperature or energy consuming. With gathering this information the power model of the VM will decide and acts in green data centers. The following picture illustrated the relationships between different parts of green VM manager [27].

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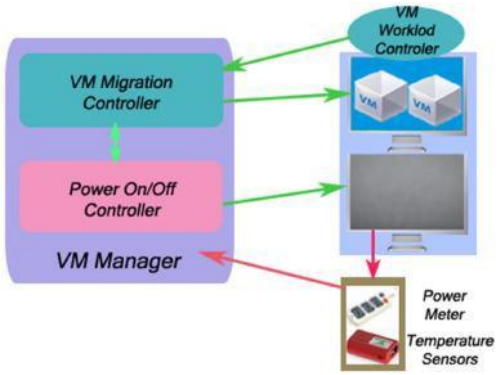

FIGURE 4. Power model of green cloud data centers

8. GREEN CLOUD COMPUTING DESIGN CHALLENGES

For designing and implementing green data centers, after all these improvements, still, there are substantial challenges that may confront. First, the challenge of the cost of the migration procedure [28] in data centers. Turning off and on of physical servers and network devices and also reallocating new resource and all these actions, sometimes uses more energy compare to the conventional ways of designing data centers [29-31]. On the other hand, differences between different IP versions still need an extra network devices which are needed more power and cannot be reduced [32-34]. Generally, the significant problem is the security issues are the significant problem. The well-known attack in VM management of data centers is DDoS. In this attack, the target is New VM creation portion and it is most dangerous attack for the cloud environment. Thus, the security issues are the considerable part of the designing the green cloud data centers.

9. CONCLUSION

The green cloud concept has an important role in reducing energy consumption in global IT industries. Thus, one of the ways that industries can reduce the energy consumption, which is followed by reduction of greenhouse gases, can be one of the solutions for having green environments. To achieve this goal, designing green cloud data centers in hardware level and also software level, will be one the solutions for IT industries.

We present a technique that used the virtual machine migration over servers based on the data center environment information in periodic manner that can reduce the energy consumption. Most of surveys highlighted server as major component, thus, the technique presented here focuses on reduction of numbers of servers which are in ON position and as a subsequence it can reduce overall energy consumption of data centers.

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