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Green Cloud and Virtual Machines Migration Challenges

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Abstract

This paper presents a green design of VM manager and migration controller which are important components of the green data center framework. In traditional cloud data centers, designing VM managers are based on the highest availability with maximizing active physical servers to decrease the down time of VMs, but in contrast, we try to meet the highest availability with minimizing active physical servers. The result will be reduction of energy consumption. Thus, to reduce energy consumption in data centers, there are different solutions for designing a VM manager and a migration controller for green data centers. The proposed method changes traditional view for designing VM manager to green VM manager by designing a VM manager and a migration controller as a one component and pointing out the challenges we should consider in new a VM manager and migration controller design. Also the green method helps data centers to reduce costs that have benefits for the cloud service providers.

Keywords: Green Computing, Green Data Centres, VM Manager, VM Migration Controller

1. Introduction

Cloud computing, currently, is one of the most efficient technologies over the IT and global application environments. Green computing means we need to reduce the number of active physical machines especially physical servers[1,2]. We can do so by controlling movement and placement of VMs (Virtual Machines) in physical servers. As we know para-virtualization allow many instances to run over one physical host concurrently[3]. Thus, to reduce the number of active physical hosts, we need to reorganize and remap the VMs in a cloud computing environment. All we need is effective VM manager in cloud computing environment. The VMs should distribute in an effective fashion that instead of simple distribution. The manager should have that ability to reduce the number of VMs in hosts and tries to reduce active physical machines to reduce overall power consumption of data center[4]. This differs from sending physical machines into the idle mode, because even an idle server may consume about two third of the peak load[5]. It goes one step forward and tries to turn the physical machines off[6].

2. About Conventional Cloud Data Center

In IT industries when you talk about cloud computing, only pros like flexibility and scalability are coming in your mind, but these amazing pros need much electricity for running the cloud data centers. The devices and hardware in cloud data centers must work uninterruptedly[7]. As shown in Figure 1, the estimations shows that how much we need to produce electricity for cloud data centers. In this figure we can see a global cloud section for electricity usage from around year 1999 to 2020[8]. It shows around 2000 cloud data center used almost 100 TWhr (TeraWatt-hours), but it increases and will be around 1400 TWhr in year 2020. This curve is evidence of the importance of controlling usage of electricity in cloud environments.

However, we know the cloud data centers are using much power, but in another research which shows in Figure 2, we can find out which parts of data centers are using more electricity[9].

Figure 2: Electricity consumption in data centers

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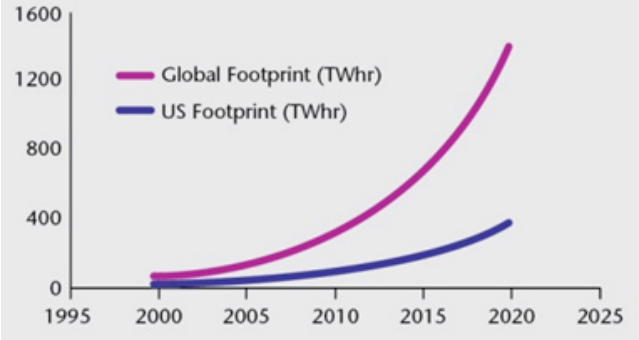

Figure 1. Projection of data center electricity use.

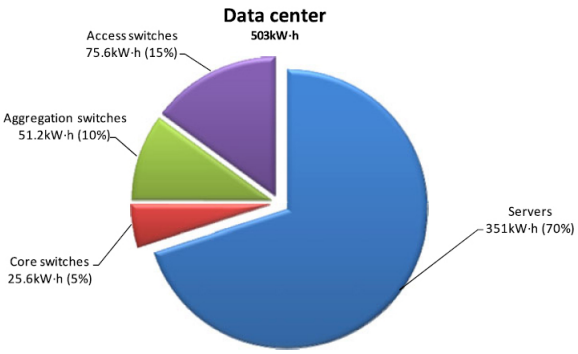

Figure 2. Data center.

The cloud data centers use switches and storage devices based on the virtualization technologies, but usually they produced base on energy efficiency packages, but still our focus on the active physical server.

As the Table 1 shows in different research[10,11], servers use more energy. Thus, how to use them has a huge impact on the energy consumption. Therefore, if data center managers can control active server, they can control their electricity usage.

One the major components in data centers are servers. Because cloud data centers designed to work with VMs, managing VMs over virtual servers are important. An important aspect of data center servers is, even when servers are idle, they consume energy. In one research[12] they experimentally calculate statistically that how the existence of VMs affects the energy consumption and with different hypervisors, which shows the importance of the designing effective VM manager and solve the challenges. The conventional 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.

Table 1. Distribution of costs in Data centers[10]

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

They try to find the idle physical servers and use those to balance load over the physical servers. As we can see in Figure 3, there is VM manager and it is responsible for distributing VMs over physical servers. In this example, the system needs another VM. After creation of new VM, based on it should not be any physical idle server, the manager will send the new VM to the Server 3 which shown in Figure 4.

3. Cloud Architecture and Work Area

The architectural model we used in this era showed in Figure 5[13]. This model consists of different tier and the area we are working on it is called "Core Middleware" and especially the VM management is an important component for us. This section will control allocating the VMs, so, we can use it for our purpose. The method used for VM migration it called live migration of virtual machines[14] that used for transferring VM in a sufficient manner that not affect user works on cloud computing.

4. Green VM Allocation and Management

The power consumption of data centers is linked to the processing power elements and also depends on the number of physical hosts on-position. Therefore, dynamic VMs consolidate is reducing the power consumption of cloud data centers[15]. Imagine that, in the peak of working hours of work days, how many requests are will send to the cloud data center? And how many VMs need to allocate and run over physical machines and hosts? But, in rest of day like nighttime or holydays, the data center does not need that much VMs to allocate on physical machines. Therefore, easily we can reduce the number of active hosts by moving and integrating the VMs in the data center.

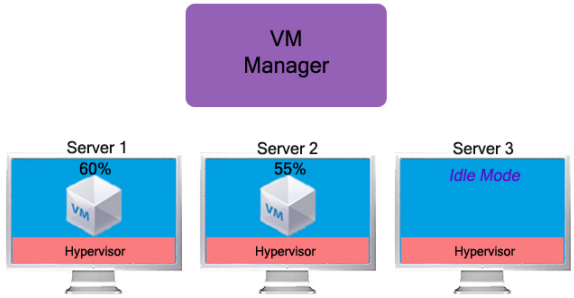

Figure 3. Conventional VM manager.

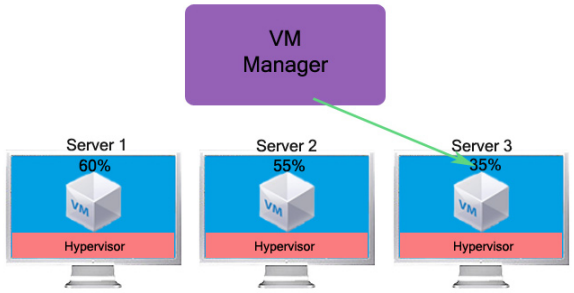

Figure 4. VM distribution.

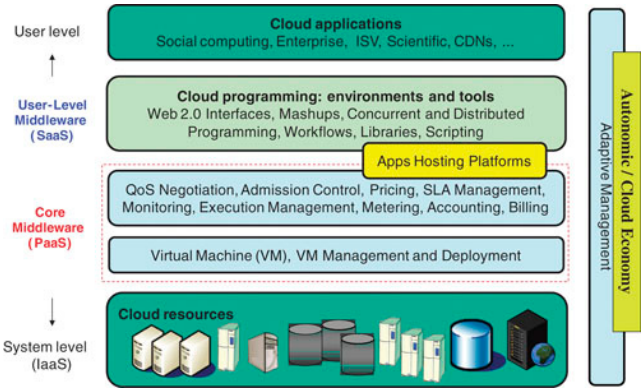

Figure 5. Layered cloud computing architecture.

In allocating VMs in different hosts, there are two types of threshold which uses to control them. One threshold is for controlling overload on physical servers and sends new created VMs to other hosts. This threshold called as "upper threshold". Another one is for hosts which VMs are in a low-level of usage and they are sources of wasting of resources which called "lower threshold"[16]. Green dynamic VM allocators is little different from the others. They are trying to utilize the system by controlling the hosts to workload near to the upper threshold of the hosts. With this action they consolidate several in middle and low working servers to one server and turn off others. Figure 6 shows the way we call it as green cloud VM management. If one server like server 3, in idle mode and new VMs needed for a new task. The green manager instead of forcing a new server like server 3 to start working again, it will find another server. It will send a new VM to the working server like server 2. It won't send it to the idle server, which is in this scenario, is server 3 and turning it off instead.

In a different scenario, if server 3 is a low loaded server and server 2 is a medium loaded server. With help of green manager consolidation, VMs on server 3 will migrate to the server 2. In this case server 3 will go to the idle mode. In the next step, same as we saw in the previous example will happen. Green VM manager make an idle physical server off, which is here server 3.

Therefore, virtual machines migration is a major part of green VM management. But, there are serious challenges to achieve this goal. In the following sections we reviewed these challenges.

5. VM Migration and Challenges

Based on the cloud infrastructure, there are different challenges in the way of migration of VMs. It could be a correct selection of the hosts or even VMs, or it could be different types of network in the data center or remapping physical resources[14]. In these situations, our management module must be prepared for all circumstances. There are two different techniques which can use for VM migration. It divides into hot (live) migration and Cold (non-live) migration[17]. The technique usually used for designing administrator tools and controlling module for migration process is based on the technique which Clark and his colleagues are introduced as "Live Migration"[14].

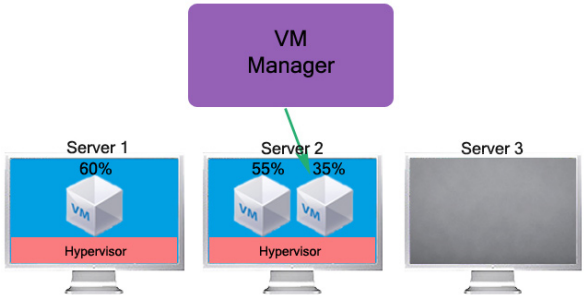

Figure 6. VM Management.

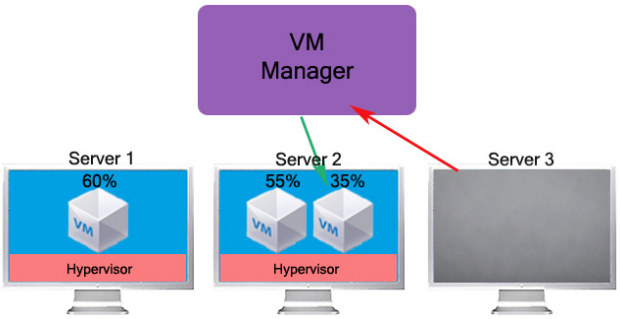

Figure 7. VM consolidation and turning off server.

Therefore, all the following sections are based on the live migration process.

5.1 Time Issue

One of the significant challenges of the VM migration is the total migration time. It is very important to reduce the "downtime" of the services that VMs can provide and it is also important for the consumers of cloud computer services. Important characteristic of the cloud computing is high availability, and all cloud providers and scientists which work in this area are pointing it out as a powerful aspect of cloud environments. Therefore time is important for designing these modules for cloud environments.

The "down time" as the name shows, it is the time which services entirely unavailable for the users. Another time which is important for us is the "total migration time" and should consider it for migration. The time that we needed for VM live migration is define as[18]: size of pages, P = {p1, …, PN}, which is equal to VM size and with available bandwidth for transferring and that is equal to "b" bytes per second. Definitely, there are the overhead times in these processes and denote as "H". Then, the time for transferring each page will be $T = \frac{P+H}{b}$ or $= \frac{VM\ Size - Overhead}{Link\ Speed}$

The transfer ends at $t_{k+1} = t_k + n_k T$, which $k = 1, \ldots, K$ is the number of pages that prepared to transfer and set of pages can be like D_k then $n_k = |D_k|$. At the end migration finishing time will be $t_f = t_{K+1} + n_{K+1}$ ((P + H) / b_d which $b_d \geq b$.

There are different algorithms for using for VM migration and each algorithm has a different down time or migration time. Therefore, it is every important to define an appropriate algorithm for our system to can manage in the best manner.

5.2 Cost of Migration

For each migration, the cost of migration is one of the aspects should consider that can effect on our road to designing green VM manager. This cost is calculates by different elements like hardware cost of source and destination, routing table and CPU load. Beside the migration cost, there is another cost in the migration process and it called as "overhead energy cost" of migration. This type of energy cost is happening when the VM is started to migrate until the end of migration process[19].

To find out average of migration energy consumption this is note as "E". We need average of power that usually used for running a source and target machines note as "P" and multiply it by time of migration which is note by "t"[20,21]. It means the energy will evaluate by: E = P * t.

On the other hand, we can be aware about the homogeneous or heterogeneous physical hosts that can consume different amounts of energy. When data begin to migrate, the consuming energy of the source host and destination host can be same as homogeneous hosts. Otherwise, it could be unequal and that depends on the hardware type that a host may use.

There is a different amount of energy the system may use in both homogeneous and heterogeneous hosts[22]. Thus, energy cost of each part of migration, source and destination, should calculate separately: $E_{mig} = E_{Source} + E_{Destination}$.

5.3 Source and Destination Host Selection Process

As we know this type of works is based on the thresholds and finding a proper VM to migrate and finding proper host to move it over there. This process can define the good VM manager or bad VM manager. One of the important issues here is how to define the thresholds in our system. For detecting hosts, dynamic management algorithm (DMA)[23] are used that can figure out which physical machine should be utilized. The VM manager which is responsible for finding a suitable target for migration, need one or more items to discover a target.

Thus, the system gathers information from physical hosts which called indexes. The data will store in index table or load table, and the system can use this information for decision making. These index tables can be built on use of CPU, memory, etc. The combination of its CPU workload, network traffic and memory usage[24] can

calculate as: $\frac{1}{1-CPU} * \frac{1}{1-Net} * \frac{1}{1-Mem}$, where "CPU" is CPU workload, "Net" is for network traffic and "Mem" is usage of memory of corresponding the virtual or physical server resources. With this process, the management system defines a label for each physical or virtual server that can use for continuing the consolidation[25].

In a green environment indexes is differs from other environments in detecting overload and under load hosts. Here, instead of only controlling workload to avoid the maximum load, we should be aware of less usage of the host also, which is known as under load hosts.

For instance, similar to Figure 8, if there are several hosts in our environment with minimum workload like 25%, 15% and 35%, then VM Manager must try to combine them and make them as one host. At the end it is only one active mode with 75% workload and VM Manager made the others as free hosts. Now, VMs on the under load hosts completely migrate from one under load host to another under load host. This action can make the some of these hosts free and unused. Thus, there are some unused physical hosts and we can send them to the turn off mode, which will be useful for decline of power consumption. This process is the consolidation process which is very important for the energy consumption in cloud data centers[26]. But there are still some challenges which we should take care of. In addition of these detections and migrations, we should also pre-calculate the costs and times of these migrations and decide these actions have good effects on our data center or not. Estimating time and cost of migration and their challenges have mentioned in previous sections. For this problem it seems the better idea is to analyze completely our data center first. If VM migration happens several times in a day, it may effect flow of data over our data center. Instead of reducing the power consumption, it may use at least same amount of energy or even more.

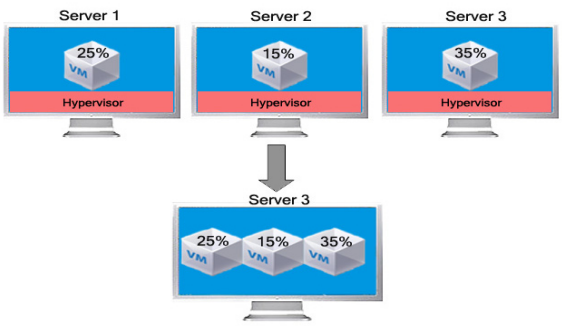

Figure 8. VM consolidation.

5.4 Creating New VMs in Target Host

Another challenge for green data centers is selecting right target host for new VMs. In conventional data center designs, all concern of the VM manager designers was about reducing the idle or unused physical hosts to reduce the number of physical hosts with no VMs. These design methods, build on reducing number of jobless hosts and activated them. Instead, in new green designing VM managers, all concentration is to increase the number of jobless hosts which are idle. Then, they will be candidate to turning them off because idle server still using electricity but off server not. By this action, the amount of electricity energy consumption will decrease.

In arrival time of new VM, the VM manager need to be aware to find the right host to put the VM on it. The host should not be in a high-level of its performance and also should not be in idle mode. Therefore, the algorithm for green cloud computing has different sides to be considered and it could be a big challenge in designing cloud data centers.

5.5 Resource Reallocation and Availability

Each VM under execution or in run mode, the specific resources are assigned to and it has its own resources and addresses. The resources are containing memory, storage and network resources. During VM migration, the best part is the memory resources which movement of host memory and the amount of data is not that much that can effect on the energy consumption too much[14,17]. The major problems here are about network and storage resources.

In VM migration process, the network resources will change and we cannot use redirection or other action on these. The VM carries its own IP during the migration process. But still we should change the physical address of the new host after the migration. There is a solution for that and it is using ARP packet[14] and broadcast it in the network. But, in some situations, because of the router configuration, the ARP packet may not send all over the network and it could be other challenges for this type of migration.

Another challenge is the storage reallocation in the VM migration process. In the whole operation, the storage array should be copy to another or move to another

storage array in the new host. Storage arrays are use to address in storage networks and they are a high-performance, high-availability solution for enterprise storage[27].

There are some techniques that used for storage migration. In one technique which is use by "Citrix" is using "snapshot/mirrored" technique. It works like this: each VM's disk is used to make a "snapshot", and whole disk's writes are mirroring synchronously to the destination storage repository[28]. Here also need twice more of storage hardware and twice more energy consumption.

5.6 VMs Migration with Different IP Version

In designing cloud data centers, IP version is one of the important issues. The designers cannot design a data center base on one of the IP versions. Therefore, they need cover different IP versions which end users may use.

Using IPv6 address provides vast space for cloud computing environment. It has scalability that can cover all the space which cloud providers need, but there is a problem. The VMs which are still using IPv4 and VM migration between IPv6 and IPv4 networks cannot be fast and we need a solution for these actions and it could be one of the important challenges in the way of reducing the power consumption in cloud data centers.

The solution for this kind of movement is based on the mobile IP technique and dual stack[29]. As illustrated in Figure 9, in one research[30] the proposed framework for cloud data centers is called as dual stack mobile nodes. In this framework they divided the data centers into three portions. The first portion used for IPv4 virtual machines, second portion used for IPv6 and the third one used IPv4/IPv6 dual stack.

From the green cloud prospective which tries to reduce the active number of the devices, using two different versions of IPs needs more devices and more devices need more energy. Also as illustrated in Figure 10, in another research[31] which seems a better solution for this problem, they used mobile IPv4/IPv6 transition framework, but still involving more devices to cover different versions of IPs.

This challenge is complex and cloud providers cannot deny the importance of the problem. But, for green data center designers is one of the major challenges that they cannot easily reduce the energy consumption in cloud data centers.

5.7 Low Bandwidth

As we know, the cloud computing is an Internet base concept. Thus, watching for needed bandwidth, especially for migration process is a major challenge. The bandwidth cloud effect the cost of migration, then designers should be very careful in designing the interconnection links in cloud data centers. But, using big amount of high-speed devices may affect the energy consumption.

5.8 Security Issues

The security issues not only highlighted in data security, here also is vital for us. The reason is hidden in nature of attacks which can effect and involve all sides of cloud data centers. One of the major attacks for cloud data center is distributed denial of service (DDoS) attacks. This attack should detect as soon as possible. DDoS attack can directly attack on the VM manager. Infected VM manager allocates unnecessary resources in physical hosts based on fake requests. It continued this process until the data center involves all the available resources to these false requests. Involving more resource means using more useless devices; thus, we should be aware of these attacks which move the data centers in the edge in different ways.

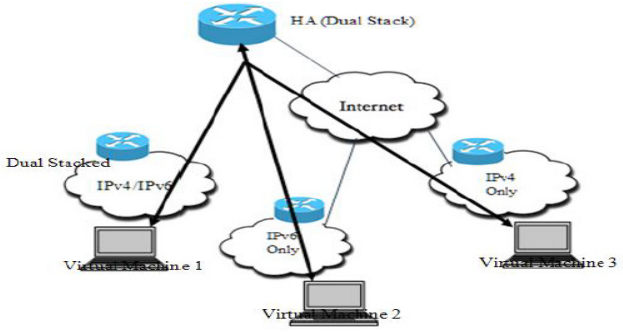

Figure 9. Dual stack mobile nodes[3000].

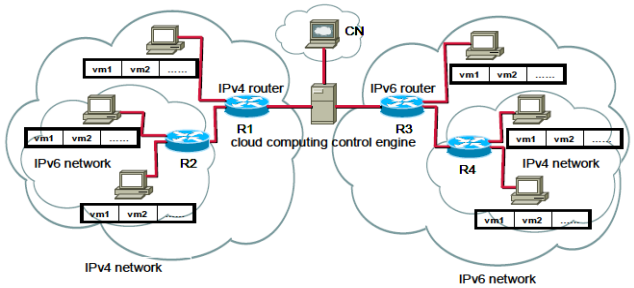

Figure 10. Cloud computing mobile IPv4/IPv6 transition framework[31].

In this case, operation of migrating of these extra VMs instead of reducing costs and power consumption, power consumption will increase exponentially.

6. Conclusion

Cloud computing still one of the favorite solutions for enterprises and every day it grows exponentially, but the way that IT industries provide cloud computing services for these enterprises is affecting our environment. The solution is to design an effective cloud data center to reduce greenhouse gas emission by reducing energy consumption. To achieve this goal new design for data centers needed and designing data centers have their own difficulties. Designing hardware and software for this new industry have its own limits and sometimes still there are challenges that researchers working on it. This paper focused on the green VM manager and VM migration operation which have a vital role in achieving the goals of green cloud computing and can effect on reducing of energy consumption.

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