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Energy Efficient in Virtual Infrastructure and Green Cloud Computing: A Review

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Abstract

Background: Cloud computing has been widely used to refer different technologies, services and concepts. It is associated with virtualized infrastructure or hardware on-demand. There exist many challenges especially in energy management on datacenter. To analyze the energy consumptions in datacenter, monitor the types of services which are offered by cloud computing to users. **Statistical analysis:** The parameters are analyzed and calculate the power usages in the different states, like server level, cluster level in the datacenter and are recorded in real time. The results are obtained at different level and helps to optimize the servers in data center, the server level optimization, consolidation and load balancing between the servers are achieved which helps to consume less in power in the cloud. **Findings:** Based on the statistical analysis, the server consolidation and optimization are required in the cloud environment. This paper mainly focused on application virtualization and desktop virtualization in cloud environment. From the identified the gap between server consolidation and optimization, created an experimental setup and continuously monitor the CPU usage, memory usage, Disk and network usage parameters. The Power consumption was calculated based on the above mentioned parameters which help to reduce the energy consumption in data center. **Applications/Improvements:** The analysis parameters are experimented in the laboratory which are helped to consume less power and reduced the carbon emission in the data center. This helps to achieves green cloud environment in data center.

Keywords: Green Cloud, Server consolidation, Virtualization, Virtual Desktop

1. Introduction

1.1 Cloud and Service Modules

Cloud computing is one of the computing paradigm by using network shared pool of computing resources. It enables computing resources as utility to end users, in small, medium and large scale organization across the world. It provides all the computing resources as service, one of the simple models is pay and use. It mainly classified as following three categories such as: infrastructure as a service (IaaS), platform as a service (PaaS) and software as service (SaaS). All the three modules the customer no needs to worry about infrastructures; the cloud provider will manage the infrastructure and provide everything as a service to customer. The cloud types such as private cloud, public cloud, hybrid could and community cloud. The cloud computing is to share the cloud services to cloud consumers, cloud partners and cloud vendors through the cloud value chain. The small and medium scale organizations adopt cloud services because it has lot of features such as cost, flexibility, scalability.

1.2 Green Cloud

The green cloud computing helps us to efficient usage of the data centers to reduce carbon emissions and energy consumption. The green strategy helps an enterprise have a positive low impact on the environment. The virtual world products such as XEN, VMware and Hyper-Vare part of the green cloud computing, those virtual products have advanced methods to reduce the computing power consumption. The simplified design of the Cisco UCS B-Series Blade Servers improves airflow efficiency and

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can reduce the number of components that need to be powered and cooled by more than 50 percent compared to traditional blade server environments. The current trend PD, VD, VDI and virtual server are used very heavily, so we should analysis existing solution and provide the recommendation to improve the effective management solution to minimize energy consumption. The services available to the users are achieved by load balance technology which helps us to reduce the down time and achieve SLA[1,2], this avoids the peak usage. Each category has different support SLA and cost. The overall goal is to minimize the power consumption and maximize performance and throughput.

1.3 Virtualization Technologies and Software

Virtualization is a proven software technology that makes it possible to run multiple operating systems and applications on the same server at the time. In the cloud computing paradigm, the virtual infrastructure has playing important role. The virtualization software called hypervisor, which is installed on the physical hardware in a virtualized datacenter, and acts as a platform for virtual machines. The hypervisors are ESX/ESXi, XenServer, Hyper-V and KVM, there are the provider playing major role in the virtual environment. The different virtualization technologies such as: Server virtualizations, Application virtualization, Desktop virtualization, Storage virtualization, Network virtualization are available in the market and it will provide the services to cloud users.

1.3.1 ESX/ESXi [3]

The general VMware datacenter diagram is given in Figure 1. VMware ESXi is the hypervisor in a vSphere environment. The hypervisor provides physical hardware resources dynamically to virtual machines as needed to support the operation of the virtual machines. The

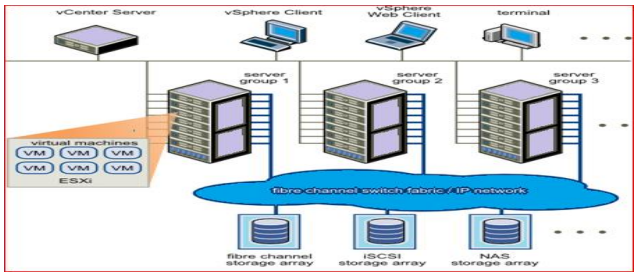

Figure 1. VMware datacenter model diagram[3].

hypervisor allows virtual machines to operate with a degree of independence from the underlying physical hardware. A virtual machine can be moved from one physical host to another, or its virtual disks can be moved from one type of storage to another, without affecting the functioning of the virtual machine. Because virtual machines are decoupled from specific underlying physical hardware, virtualization allows you to consolidate physical computing resources such as CPUs, memory, storage, and networking into pools of resources that can be dynamically available to virtual machines. With appropriate management software, such as vCenter Server, which can use a number of features that increase the availability and security of your virtual infrastructure.

1.3.2 XenServer [4]

Citrix XenServer utilizes the powerful open-source Project Xen Hypervisor. XenServer is designed for efficient management of Windows and Linux Virtual Machines (VMs) and delivers cost-effective server consolidation

1.3.3 Hyper-V [5]

Hyper V is an infrastructure virtualization solution developed by Microsoft for server virtualization. It is one of the hypervisor approach used for hardware virtualization. It supports multiple guest operating system support.

1.4 Virtualization Techniques VM Migration

Resource Schedulers: VMware vSphere vMotion enable Distributed Resource Scheduler (DRS), which balances host utilization and supports scheduled maintenance. It also helps VMware Site Recovery Manager put VMs back into service when unexpected failures occur.

2. Related Work

The existing load balances algorithms and server consolidation methods are Honeybee Foraging[6], Biased Random Sampling, Active Clustering, Compare and Balance Round Robin Algorithm, Opportunistic Load Balancing Algorithm, Min-Min Load Balancing Algorithm, Max-Min Load Balancing Algorithm, Two Phase Scheduling Load Balancing Algorithm (OLB-Opportunistic Load Balancing + LBMM- Load Balancing Min-Min). Server consolidation methods and Cloud Server Optimization such as: DVFS (Dynamic Voltage

and Frequency Scaling)[7], Active Cooling, Automatic Migration-Trigger Engine, Combination of allocation and Migration, VM Allocation and consolidation[8] using Ant Colony optimization, Selection Policy, Transfer Policy, Location Policy, Information Policy.

The theoretical analysis of Virtual Infrastructure consolidation algorithms is used to obtain theoretical performance estimates and insights into designing algorithms. The existing power saving techniques Resource throttling, Workload consolidation, DVFS (Dynamic Voltage and Frequency Scaling), DCD (Dynamic Component Deactivation). Modified Best Fit Decreasing (MBFD)[9] Algorithm, Bacterial Foraging Optimization Algorithm (BFO)[10], green scheduling algorithm[11], Devising the algorithm[12] are effective management and decision making tools, which will lead less power consumption for green computing. These technologies mostly concentrate on system resources such as CPU, Memory. These techniques are used in OS level and Datacenter. Load balancing technique will apply on the application level access and customize the application usage with high level performance.

Energy consumption in transport and switching[13] can be reduced significantly in total energy consumption of cloud computing. The novel Green Cloud framework[14] for improving system efficiency in a data center. The CUE (Carbon usage Effectiveness)[15] is a measure of carbon dioxide emission in environment by all data centers. The Power Usage Effectiveness (PUE) is PUE =Total facility power/IT Equipment power used to calculate the power usage.

The skewness[16] is to quantify the unevenness in the utilization of multiple resources on a server. The DC Sim[17] is one of the simulator help VMs migration during workload analysis. Green Cloud Simulator[18] is a well-known simulation tool which offers a fine-grained simulation of modern cloud computing environments focusing on data center communications and energy efficiency. The mvcluster[19] which is the extended version of vcluster in order to support multiple experiments in a single virtual cluster.

The application virtualization is one of the huge areas in the cloud computing environment. The private cloud will provide application virtualization to their users based on their requirement based on their job. Even the private cloud provides services to their users to access the virtual world across global and around the clock. The application provisioning will provide with help of the server groups. The group of servers configured to provide application provisioning to user it might be a single application or group of applications. The users can use n-number of applications based on the requirement and privilege in the private cloud.

Problem-1: The end user aware only the application, whenever required, click the application, it will be launch and accessible to users. The different components of the physical desktop, virtual desktop and dynamic provisioning virtual desktop are listed in Table 1. But in the back end, it had configured using lots of infrastructure servers, application servers and database servers based on the

Table 1. The Components of physical desktops, Virtual Desktop and Dynamic Provisioning Virtual Desktop

Components	Physical Desktop	Virtual Desktop	Dynamic provisioning Virtual Desktop
Location Independence	No	Yes	Yes
Efficient Resource Management	No	Yes	Yes
Scaling up and Scaling down resources	No	Yes	Yes
Improved utilization	Yes	Yes	Yes
Administrative support	High	Low	Low
Hardware Reuse	Yes but limitation	Yes	Yes
The life time very limitation	Yes	No	No
Resource additional CPU	No	yes	Yes
Resource additional RAM/Memory	Limitation	Yes	Yes
Resource additional Storage/Hard disk	Limitation	Yes	Yes, but some situation we can add as additional drive, does not extend existing system drive.
User settings will retain	Yes	yes	Based on the provisioning configuration the user settings / desktop will retain or destroy.

application requirement and user load. Most of the time, the application load will not utilize maximum load, sometime the load will peak and low. Based on the user load we should accommodate the servers to handle the user requests. So, can add and remove servers such as power on and power off additional servers based on the application requirement and user's load.

Problem-2: The desktop virtualization is one of the emerging areas and it is part of the application virtualization, need to follow server optimization and customization. Table 2 summarizes the desktop states, its power usage and resource usage. In this case, need to identify the gap and make optimization which will help to reduce the power consumption. In the real time scenario, the desktop virtualization provisioning not only stick with single method, they will design and use the environment, based on their requirement. Every method will have their own merits and demerits, but need to understand the user requirement. The users such as application developers, application and infrastructure administrators, application users, each user's categories usage and time will be different. The application developer, infrastructure administrator required dedicated desktop. The design environment catalogs should be concentrating the elements such as users, usage and categories. The effective design it helps us to manage environment optimized way. In the cloud environment one of the major issues is design part. But in the private cloud it will organize smart manner. The effective design and optimization helps us to optimize usage of desktop and reduce the power consumption which leads to minimize the power usage and carbon footprints.

Table 2. The desktops state, power and resource usage

Desktop state	Ready	In-Use	disconnect	Power Off
Power usage	Normal	High	Medium	No
Power use Min	yes	No	No	No power use
Power use Max	No	Yes	Yes	No power use
CPU usage	Normal	High	Medium	No CPU usage
Disk usage	Normal	High	Medium	No Disk usage
Network usage	Normal	High	Medium	No Network usage

3. Experimental Setup

The ESX cluster contain around 6 host machines each machine Intel Xeon CPU E7-2860 @ 2.3 GHz configuration support20Core and logical process40 with couple of TB RAM and SAN storage. The each ESX machine capable of handle either around 30+ windows 2008 servers or 70+ virtual desktop windows 7 defense upon the configuration. The ESX configured High availability and DRS. The DRS migration configuration is fully automated and the migration Threshold applied: Apply priority1, Priority2 and Priority3 recommendations.

The window 2008 server was configured with 4CPU and 16GB RAM and required applications to support the user on the cloud. The virtual desktop configured with 1CPU and 2GB RAM with special requirement of 2CPU and 4GB RAM was provided.

4. Performance, Experimental Results and Discussion

4.1 Server Optimization

A real time experiment was conducted with the application names called X, it was used by the global users, each server can handle 100 users and maximum users load will be 10000. This load requires 100 servers to handle the maximum load. But, the maximum users will not access the server throughout a day. There will maximum of 12 hours per day; the load will be peak and rests of the time the load will less than 2000 users. In this situation all the 100 servers do not required to be in ON state, hence can customize around 65% of servers to be ON state and rest of servers can be powered off. This will help to achieve low power consumption and less carbon footprints. Figure 2 shows the VM Migration and consolidation are analyzed using available resource pool in the cloud. This was helpful for server optimization and reduced the power consumption

4.2 Desktops in Cloud

In real cloud environment play important roles are played by the physical desktop, virtual desktop and dynamic provisioning virtual desktop. In the desktop virtualization, it provides dedicated and non-dedicated desktops

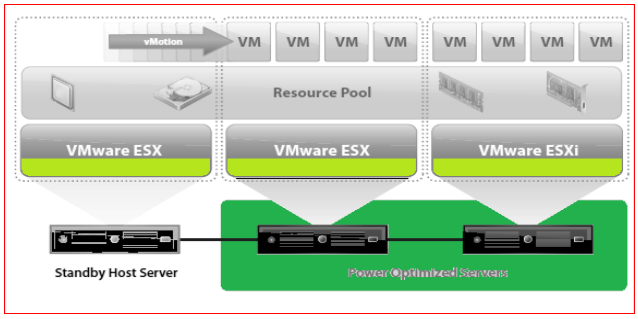

Figure 2. VM Migration and consolidation using resource pool [3].

for virtualization. The requirement and provisioning are based on optimization in the back end ESX/ESXi/XenServer. The users cannot identify the desktop whether it is physical or virtual desktop, but the user can use desktops for their works.

4.2.1 Physical Desktop

The physical desktops can be used in the virtual environment, but it has limitation such as fixed CPU, fixed Memory and storage. If any upgrade in hardware level, the cost is high and compatibility will be limitation.

4.2.2 Virtual Desktop

The virtual desktops can be used in the real time virtual environment. Depending on the applications and user requirements, the desktop customization and hardware selection are done. Once, selected the configuration for virtual desktop, it will be deployed in one place and created as virtual desktop. The deployed desktops are provided to users based on the dedicated or non-dedicated and pooled environment. In dedicated desktop, the user can use and save their configuration settings for their application. The users can install additional software's and tools based on their privilege, the modifications will be saved on user desktop. Some users may have privilege on application usage that will be specific to IP address, it will be allowed through firewall to access applications such SAP based applications. If the users required additional CPU, Memory and storage that can be accommodate in virtual desktops.

The pooled desktop will be shared to couple of users; it will be managed through their profiles. The modification will be saved on their user profile, but it has limitations. The non-dedicated desktop will be provisioning to users dynamically; once the user completed their activity, it will be destroyed immediately.

4.2.3 Dynamic Provisioning in Virtual Desktops

The dynamic provisioning in virtual desktop plays major role in real time environment. The dynamic provisioning will help us to serve large scale with the help of powerful virtual infrastructure. In this case, it provides, manage the dedicated and non-dedicated virtual desktop to users. In this design, the desktop creation plays by the provisioning of delivery controllers. The golden image is used as template, and will deploy base image from the template. The base image will act as base image and the rest of the defined virtual machines run as snapshot. In this design, the resources are used in effective manner. The dedicated desktops provision given to users and installed required software and tools by the user based on their privilege. The changes will be stored on the user desktop. In pooled desktop, the user can use and install the required software's and tools based in their privilege, and changes will be retaining in their desktop, which is depicted in Figure 3.

Dynamic provisioning in virtual desktop will not retain the user's data or modifications. In dynamic provisioning, whenever the user logged in and it will provide as new desktop, once the user completed their activity and logoff or shutdown, the user settings will be destroyed.

Logon process: The following steps will be involved in logon process

User logon to the application portal
User able to view the desktop icon
User click to access desktop icon
If the user desktop is power on state
User can access desktop
Else power on user desktop and will launch desktop
User can access desktop

Logoff process: The following steps will be involved in logoff process

User click logoff to exit
If the User logoff from desktop, it will go to ready state.

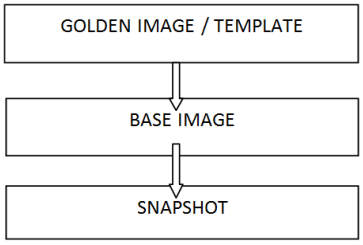

Figure 3. VM provisioning.

User click disconnect to exit

If the User disconnect from desktop, it will go to disconnected state.

User click shutdown to exit

If the user is click shutdown, it will be power off state.

User logoff from portal

Server Optimization in virtual desktop on cloud: The desktop state will be ready, disconnect, in-use and power off. If the user is active state, it will be in-use state.

The Figure 4 shows test case of Virtual Machine CPU usage, in this graph the x-axis represents the percentage of CPU usage in MHz and the y-axis shows the time in ms. The power usage will varies based on the system performance. In this test case, VM uses the maximum of 61% of CPU and minimum of 4% of CPU.

4.2.3.1 CPU Parameters

The Figure 5 shows test case of VM power usage in watt. In this figure, x-axis represents the watt and the y-axis represents the time in ms. The power usage will varies based on the system performance in the cloud. In this case, test-VM uses the maximum of six watts have been utilized at one time. Even in idle desktop, some process will be relay by the user, it will lead to maximum power consumption.

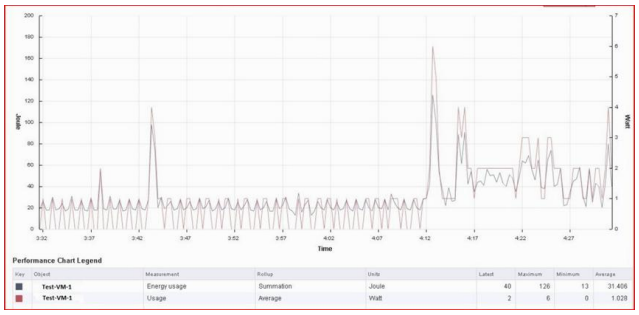

Figure 4. VM CPU usages in MHZ and Percentage.

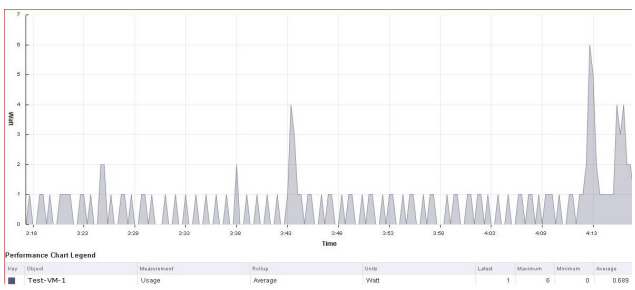

Figure 5. VM power usages in watts.

The Figure 6 shows test case of VM memory consumption status. In this figure, the x-axis represents the percentage of memory usage in KB and y-axis represents the time in ms. The system performance and power usage will varies based on the memory and CPU usage of cloud systems. In this test case, test-VM uses the maximum of 53% and minimum of 21% of CPU have been utilized.

4.2.3.2 Memory Parameters

The server optimization used to handle desktop categories to optimize power usage. The private clouds are designed to support up to 500 users globally, in this desktops are categorized based on the user group and their usages. The desktops are used round the clock. To accommodate all of these requirements, the backend is equipped with XenServers/ ESXi servers which are placed in cluster environment. The design part, the desktop VM created as template and deployed as desktop machines and assigned to concern catalog services. Each catalog contains number of desktops and is assigned to concerned users. The users can access their desktop through the portal. The user may access the portal through intranet or internet. The most of the users will access their desktop in their business hours. The optimization techniques should use to minimize the down time& maximizes the throughput and trim the idle desktops, unused desktops.

If the user logoff from desktop, it will go to ready state. It will be identifying by the monitoring and power shell script put into power off state.

If the user disconnects from desktop, it will go to disconnected state. It will be identifying by the monitoring and based on active time setting it will put into power down state.

If the user is click shutdown, it will be in power off state.

Figure 6. VM memory consumption.

4.2.3.3 User Logoff from Portal

The customization will monitor the desktops and if the users will logoff their session, the desktop should go to power down state. Based on the region and catalog, the active time will be defined, once it reached the active time, the concerned desktops will be shut down and goes to power off. In this case the active desktops will not shutdown, only disconnected and ready state desktop will go to power off state. This action lead the backend servers will be in VM allocation and consolidation, being active and the unwanted resources are eliminated and down the server.

5. Conclusion and Future Work

The existing theoretical performance of an online algorithm is evaluated. The identified existing gaps on server optimization and load balancing techniques are brings energy efficient usage in virtual infrastructure and green cloud computing. The experimental setup, continuously monitor the CPU, Memory, Disk and network usage and calculated the power consumption in the cloud environment. The calculated power consumption helps to take strong decision and helps to reduce energy wastage. The load balancing techniques are applied in application level access; customize the server optimization, the applications which are running in the cloud provides optimum performance. The intelligent management recommends accommodating the minimum energy usage and reduce the carbon footprints in cloud computing.

The work was evaluated by setting up small private cloud and provides the application level provision to the cloud users. This setup can further improved and make it as public cloud environment to meet the real time challenges. The intelligent management recommendations help us to get real cloud green computing. The optimization, threshold values are obtained and match with the user's requirement with in SLA and improved the through put in cloud.

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