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A JOURNEY FROM VIRTUAL INFRASTRUCTURE TO GREEN CLOUD COMPUTING(Camera ready copy)

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ABSTRACT-In a cloud value chain, the major goal is to share the resources and services among the cloud partners, cloud vendors and the cloud service consumers which have to be enhanced. Recently the IT industry is growing rapidly to imbibe the concept of "Green". Apart from considering the cost perspective, it is concerned about making our earth a better to live by reducing waste and non-toxic materials. The power efficiency can be maintained by utilizing technologies like virtualization. Virtualization of data center components which make use of techniques like virtual provisioning, deduplication, virtual machine migration etc., has enriched the load balancing and recovery of servers on data centers. This paper presents an overview of the enabling technologies like virtualization and green computing that paved thewayfor the emergence "Green cloud computing".

Keywords: Cloud computing, Virtualization, Green computing, Green cloud computing, Green data center, power management, Environment Access.

I. INTRODUCTION

There is an increase in on-demand large-scale computing services provided by data centers, which work with a huge number of servers together with infrastructures as networks, storage, and cooling systems. The concept of green computing, also known as green technology focuses on the environment-friendly utilization of computation devices. Services provided through this kind of computing will be capable of attaining economic viability to business. Approaches like green manufacturing, green design, green use and green disposable not only facilitate the creation of energy efficient computers but also making use of them in an eco-friendly manner. Green computing is the environment and eco-friendly responsibility of computers and their resources together.The Environmental Protection Agency(EPA) launched the Energy Star Program(ESP) which facilitated the espousal of green computing practices in 1992. Green computing aims to reduce cost of power consumption, maximize the revenue for business, ensures controlled carbon emission, avoids toxic substances, avoids pollution, reduces harmful effects caused due to increased utilization of computing resources, reduces computing waste thus providing a greener solution to the problems caused by the current practices followed in manufacturing, using and disposal of computing resources.

With data centers occupying the central portion of computing infrastructure in today's world, the need for aligning the principles of green computing gets aligned towards the adoption in data centers. The consumption of ahuge amount of energy due to data transfer increased pollution, emission of toxic substances from the data centers waste, increased power consumption, reduced expenses in terms of maintenance of data centers elevate the need for application of green computing practices to data. Green computing technology adoption to data centers will enable them to consume thecomparatively lesser amount of energy when compared to classic data centers. Beyond the implementation of green computing services, cloud service providers such as Amazon, Yahoo, Google, eBay,etc., which consists of a large number of datacenters, may imbibe the green concept by consolidating their data centers.

A data centers paved way for delivering services through cloud uses virtualization as the first step towards enabling green computing adoption. Virtual infrastructure utilization though not capable of complete migration to a green computing technology scenario, supports techniques for efficient power management. Backup and recovery in data centers are the prime source of energy consumption in data centers. Techniques such as deduplication that are used in case

of virtualized data centers apart from enabling optimized use of energy, ensures availability,higher performance and thus achieving business continuity.

II.VIRTUAL INFRASTRUCTURE

As the delivery of services through internet had commenced, availability of services has become the prime demand of the users. Ensuring availability requires the employment of a large number of servers and active networks. Apart from the demand of users, there are applications that cannot tolerate downtime. For example in thecase of financial transactions not only the downtime is a consideration but also the sensitive data associated with applications. In such cases, the need for backup infrastructure arises. The deployment of classic data centers witnessed the utilization of a large number of servers andits maintenancehad become a tiresome task to the IT managers. The cost concerns of the managers were particularly on the management and maintenance of such resources. The emergence of virtual infrastructure became an all in one solution to address such issues. By utilizing the concept of virtual machines, a single system may accommodate a number of virtual machines depending on the capacity of hardware resources. This means that a single computer can incorporate number independent computers.This kind of setup will not only be able to accommodate a number of resources but also contributes to areduction in power consumption, simplified resource management, lower cost of maintenance and other related tasks. Virtualization concept is not only restricted to servers but also to networks, storage, desktops, and applications and even to the maintenance of user state.

Compute virtualization/Server virtualization: This type of virtualization enables the server to host multiple virtual machines on it and thus making efficient utilization of the computer resource in a data center[2].

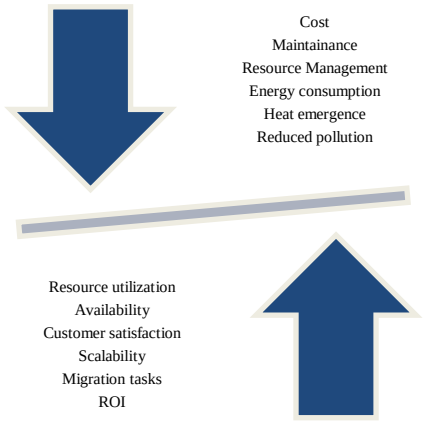
Network virtualization Enables usage of the network resources by virtualizing them. Virtual networks may be employed to communicate among the virtual machines enabling simplified network management tasks. This enables efficient utilization of the network bandwidth allocated.

Storage virtualization: The most beneficial type of virtualization which simplifies the storage on disk arrays by making use of LUN's and allocating each LUN to a virtual machine. Apart from this storage on the servers can also be virtualized to achieve higher benefits.

Desktop virtualization Brings down the cost associated with the purchase and maintenance of PCs by making use of techniques like theremote desktop interface and virtual desktop infrastructure. This enables the user to operate desktop system present in remote locations in a networked environment.

Application virtualization: Enables the utilization and application related data without the need for installing applications. The applications and its related data can be used on demand over the network as required by the user.

The benefits of virtualization are very high and can directly impact several factors like cost, resource utilization, ROI etc., The benefits of virtualization on par with the industry needs is illustrated in the following figure.



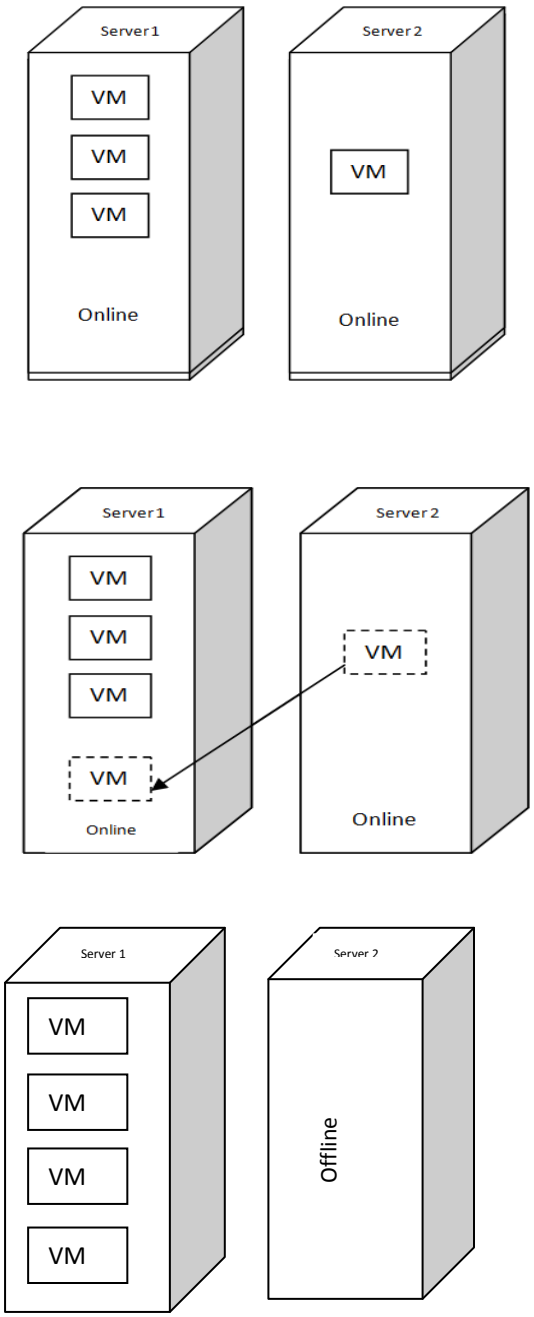
By making use of this setup it is possible to accost to the concept of green computing. This kind of infrastructure is a boon to IT managers in terms of resource management and maintenance, lowered cost and achieving higher customer satisfaction in terms of the service providers and thus giving itself a welcome to various stakeholders. The migration to virtual infrastructure is considered as the first step to achieving a greener data centers and in turn green cloud computing.

III. VIRTUAL MACHINE MANAGEMENT

The process of allocating and de-allocating the virtual machines dynamically on physical machines can complement to scheduling jobs in thedatacenter. The load on the servers is rapidly increasing and hence the need to balance the requests on the servers is not only the

responsibility of the individual servers but also the network. Virtual machine management task can be effectively handled by virtual machine migration. This migration task can be done dynamically or can be scheduled depending on the need. Virtual machine migration task can be done for various application which includes ensuring higher levels of availability, as a disaster recovery mechanism, power management, resource management etc.,

For example, consider there are two active servers which host virtual machines on them.



The above figure illustrates the virtual machine migration task on two servers. It can be observed that the storage availability in Server 1 enabled the migration of the virtual machine that was present in Server 2 and thus making it offline and hence reducing the power consumption. In this way it may be found that there is a link between the number of active servers, the amount of power consumed and the amount of heat dissipated and the load on the cooling systems in a data center.With such kind of virtualization principles, there is much scope for reducing the energy consumed by the servers and thus reducing the amount of heat emerged from these servers and therefore bringing down the exertion of cooling systems.

IV. VIRTUALMACHINE POWERMANAGEMENT

The potential of virtual infrastructure aids in the efficient power management of resources. Servers occupying the major portion of the data center can host to several virtual machines.The deployment of virtual machines on the servers[3] requires proper management as there are instances where all the virtual machines need not essentially be running on the servers all the time. For example, consider the scenario where a full backup of virtual machine A is to be done on another virtual machine B. In such cases, the virtual machine B may not be required to be running all the time. It would be sufficient that it may be powered up during the backup task. It may be observed that scheduling and virtual machine management become essential functions in case of utilizing a virtual machine infrastructure. Instances like these are the motivation for the adoption of green computing to the traditional computing tasks.

Apart from such native benefits offered by virtualization in thecase of power management, there are few other means of regulating power usage in VM environments. This involves the monitoring of how the hardware components use and deliver power, by monitoring how the virtual environment use the hardware resources and by devising mechanisms for adjusting the capacity and load. Scheduling power to the servers has always proved to be an efficient means of power management. Dynamic scheduling of virtual machine migration is the most effective means of regulating power to the hardware resources thereby monitoring the energy consumption. There are several inbuilt mechanisms for power management task that is packed with VM based products. There are several algorithms that enable VMs power management based on ascheduling algorithm. Apart from using such algorithms in a data center, it is essential to focus on the cooling mechanisms employed in data centers. The energy consumption of these cooling systems is very high and mechanisms for managing such systems are at a very nascent stage. Hence such algorithms at the virtual machine level in server consolidation prove to be one of the

most effective means of power management for data centers.

V.GREEN COMPUTING

Virtual Infrastructure To Green Cloud Computing

The answer to the question of "Can cloud be green?" became yes with the emergence of the server virtualization. It was capable of optimizing the energy requirements of the data center.Several other factors like large space requirements for a data center, bringing down the work of cooling, lighting and climate control systems.

Virtual data centers were capable of achieving higher levels of availability and in turn enhancing the performance of applications. Though the concept of virtualization contributed to themanagement of power and energy it still had not achieved its target of going green. This is because the workload was shifted to the working of few servers leading to thehigh emission of heat from these servers and the problem of carbon footprinting was not resolved. A virtual infrastructure can aid to provide green computing services only if the server utilization is achieved to the maximum by considering the energy requirements and carbon footprinting.

Green computing on the broader terms is defined as the study of designing, manufacturing, using and disposing of computing devices in a way that reduces their environmental impact. Green computing takes up the environmental responsibility of making the computing devices to provide eco-friendly services to the users. The awareness of "Go Green" has invaded the technology society making them imbibe the concept of making energy efficient utilization of resources. The evolution of virtualization concept made it possible to make energy efficient utilization of resources. Going green in computing perspective embarks on the manufacturing of the devices and terminates with the disposal of those devices. It can be understood that beyond the utilization, green computing wraps up the concept of green throughout the lifecycle of a computing device.The Green computing follows the 6R technology which includes

- Reduce
- Reuse
- Recycle
- Reinforcement
- Renew
- Responsibility

The concept of green computing may easily be aligned to smaller computing task but it becomes a challenge when it has to get itself adapted to providing services which demand a high level of availability and reliability.

Cloud computing is one of the most popular means of providing services in the recent times. It makes use of data center as the backbone and it has commenced incorporating virtualization technologies as the first step to making itself green. Cloud service users demand ahigh level of availability and reliability from its service providers as scalability has become the built in feature of cloud computing. To ensure availability to its users, it has become essential to employ a number of servers for backup and other related tasks.

Green cloud computing is similar to that of the traditional cloud computing service and is capable of providing software, infrastructure, and platform as a service.The concept of green cloud computing enabled the business users to maximize the ROI as well as reducing the carbon footprinting without affecting their markets. The service providers who wish to provide green cloud computing service need to be registered with the Carbon Emission Directory that maintains a list of cloud service providers, their corresponding energy utilization for providing service, QoS etc., The green cloud computing services are provided to the users in a way such that the provisioning of cloud services has comparatively lesser carbon emission. Green cloud computing makes use of a special type of middleware called green broker which enable the user to make use of the services provided by the greenest service provider.

The components of the green cloud computing architecture [1] are listed

GRA (GreenResourceAllocator)

Green resource allocator acts as an intermediary between the service providers and the consumers.The green resource allocation algorithm makes use of the green resource allocation algorithms as in [4] [5] [6] [7]for its efficient functioning based on the service provisioning functionalities. It makes use of the following components to support energy efficiency.Green Negotiator is obtained the aid of the green broker to parley the Service Level Agreement between the consumer and the cloud service provider which include the description of the consumer's energy saving plans, the Quality of Service expectations etc.,Service analyzer receives the request that is provided by the consumer, analyzes it for the current load and energy requirements, processes user request based on it.Pricing determines the amount that is charged for the processing the service requested.

An energy monitor is responsible for the power management of the physical machines by statically/ dynamically assigning the time for switching the physical machines on or off. Virtual Machine monitors are responsible for managing the availability of resources by managing the migration of VM across physical servers.

Methods To Implement Green Cloud Computing

Green cloud computing may be achieved by incorporating the following technologies.

- Virtualization
- Carbon Free Computing (CFC)
- Solar Computing
- RoHS Computing

A. Carbon Free Computing (CFC)

The Carbon Free computing is defined as a set of programs or any other instructions and their relative products have to be designed to manage and control their own individuals and its organizations to reduce its impact factor on its environment as eco-friendly.

Focus of CFC initiative include,

1. Participates about tenders and sales with its Green cloud requirements.
2. Promotes their CF PCs to be built across a Green working cloud Environment.
3. Spreads their awareness to its alternate solutions areas,
    - Energy conservation
    - Power management
    - Power Supply
4. Helps to organize their levels of carbon has to be released to their environment.

B. Restriction Of Hazardous Substances Directives (RoHS)

RoHS directive that took effect since 2006 gives directive control over the restriction and use of some hazardous substances in electrical and electronic components of devices. TheRoHScommonly referred to as 'lead-free directive' restricts/limits the usage/emission of the following substances in the manufacture/utilization of computing devices

- Lead
- Hexavalent chromium
- Mercury
- Polybrominated biphenyls
- Cadmium
- Diisobutyl phthalate
- Butyl Benzyl phthalate
- Polybrominated diphenyl ether
- Bis(2-ethylhexyl)phthalate
- Dibutyl phthalate

C. BENEFITS

The benefits of green cloud computing are beyond the benefits of traditional cloud computing as it incorporates the environmental responsibility. It is capable providing several advantages to various cloud service stakeholders. It includes

- Improved power savings
- Reduced cost
- Recycling of products as well as software
- Eco-friendly and environmentally friendly products
- Remote Access
- Self-service provisioning
- Ease of Use
- Increased response time
- Reliability and Fault Tolerant
- Scalability
- Increased Storage

VI.CONCLUSION

The cloud computing infrastructure has an increased and required the need for saving energy, power saver mechanism on within the cloud platform. This paper focuses on the various enablers that paved the way to the journey of green cloud computing. The proposed system will be capable of optimizing the energy requirements of the data center. Several factors like bringing down the work on cooling, spacing for data centers, climatic controls change controls. This makes the better performance on the environmental access. All by means, energy conservation of Green computing needs to be an integrated cycle of logistics problem with its solution under processing,transport, and its storage can be computed together with the predominant cloud computing tasks with low intensity among the conventional computing with its own PC. The power saving techniquesinclude the utilization of advanced virtualization and cooling system is always a beneficial greenest cloud computing technology. On using this, one can easilybe accessed and increases the storage capacity in data centers.

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