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Power Efficient VM Consolidation using Live Migration- A step towards Green Computing

Gaganpreet Kaur Sehdev[1], Anil Kumar[2]

[1]Guru Nanak Dev University, Department of Computer Science, GT Road, Sharifpura 215/13, India

[2] Guru Nanak Dev University, Department of Computer Science, GT Road, India

Abstract: ***From past the researchers have seen a brusque changes advent in the field of research areas on maturing the energy efficient large computational resources. Here firstly the basics of Cloud Computing discussed and then green computing with its architectural elements, power efficiency, live migration are presented. A novel Green computing framework is applied to the Cloud in order to meet the goal of minimizing the power consumption. This paper tries to impose efforts on power management with Live Migration. In Live Migration a running VM is moved from one physical host to another. Live migration is attractive to data center providers because moving a VM across distinct physical hosts can be leveraged for a variety of tasks such as power management, maintenance, or fault tolerance. Power consumption has found to be critical come forth in Cloud environment. Also servers take much energy to finish their tasks. Green computing comes up to overcome the energy consumption problem in cloud computing.***

Keywords: Cloud Computing, Green Computing, VM management, Power efficiency, Live Migration.

1. Introduction

Cloud is Common, Location-independent, Online Utility provisioned on-Demand. Cloud computing has recently revealed technology that is used for hosting and delivering services over the Internet. Figure 1 shows the diagrammatical representation of Cloud Computing.

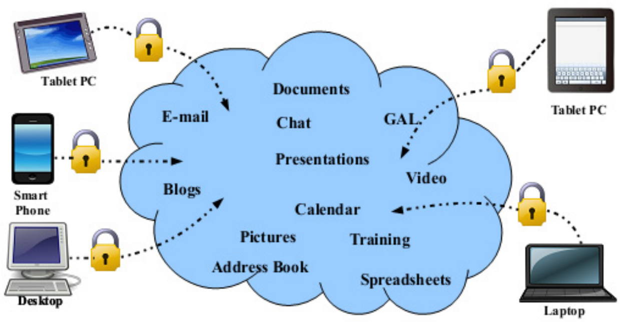

Figure 1: Cloud Computing [8]

The definition of cloud computing provided by "The National Institute of Standards and Technology(NIST)",Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction [1].

1.1 Service Models

The cloud offers 3 different service models. These service models are [2]:

IaaS
PaaS
SaaS

Figure 2: Service Models

a) Infrastructure as a Service (IaaS)
IaaS layer virtualizes computing power, storage and network connectivity of the data centers, and offers it as provisioned services to consumers. Examples are Amazon EC2, Microsoft Azure Platform.

b) Platform as a Service (PaaS)
PaaS, often referred as cloudware, provides a development platform with a set of services to assist application design, development, testing, deployment, monitoring, hosting on the cloud. Examples are Google App Engine, Microsoft Azure.

c) Software as a Service (SaaS)
In SaaS, Software is presented to the end users as services on demand, usually in a browser. Examples are salesforce.com, google apps.

1.2 Deployment Models

Cloud deployment models can be classified as private, public, community, and hybrid cloud [2] [9]:

a) A Private cloud is owned or rented by an organization. An example of this model is a cloud built by an enterprise to serve their business critical applications.
b) A Public cloud is owned by a service provider and its resources are sold to the public. Examples are Amazon, Google, and Microsoft.

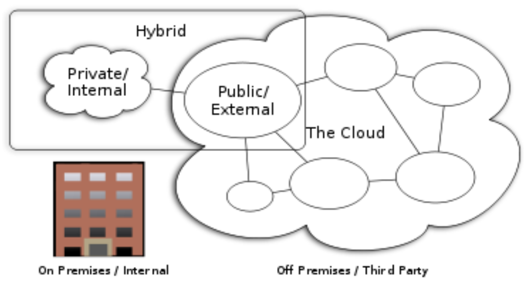

Figure 3: Types of Cloud Deployment Model [9]

c) A Community cloud is similar to a private cloud, but where the cloud resource is shared among members of a closed community with similar interests.
d) A Hybrid cloud is the combination of two or more cloud infrastructures; these can be private, public, or community clouds.

1.3 Green Computing

Let us review the basics of a Green cloud Computing. It refers to envisioned of not only accomplishing the efficient processing and use of computing environment, but also reduces the energy consumption. The goal of being green is reducing carbon emission that causes global warming. The most important reason of CO2 emission is energy consumption, so reducing energy consumption not only means conserving more energy sources for the future but also means reducing CO2 emissions.

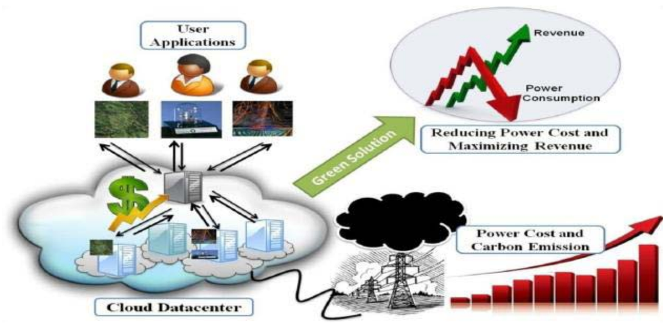

Figure 4: Cloud and Environmental Sustainability [19]

To direct to this problem, data center resources need to be managed in an energy-efficient manner to drive Green Cloud computing [16] [23].

2. Related Work

With the advent internet in the 1990s to the present day facilities of ubiquitous computing, the internet has changed the computing world in a drastic way [2]. Cloud computing is a recent trends in IT that moves computing and data away from desktop and portable PCs into large data centers. There is a discussion on architectural design of cloud computing, its applications and issues that are security and privacy with its solutions.

Cloud computing is a popular enterprise model in which computing resources are made available on-demand to the user as needed. It provide a comprehensive study on the motivation factors of adopting cloud computing, review the several cloud deployment and service models [3]. There explore certain benefits of cloud computing over traditional IT service environment-including scalability, flexibility, reduced capital and higher resource utilization-are considered as adoption reasons for cloud computing environment. At last, it includes security, privacy, internet dependency and availability as avoidance issues.

In the authors discussed on Cloud Computing that has become a scalable service consumption and delivery platform in the modern IT infrastructure [4]. The architecture, types of cloud, barriers to cloud, and creating an instance in Amazon has been discussed. Besides, the usage of Traditional Enterprise Datacenter Utilization, Virtualized Enterprise Datacenter utilization and Cloud Enterprise Datacenter Utilization are compared.

Virtualization is an abstraction of computer resources [5]. The purpose of virtual computing environment is to improve resource utilization by providing a unified integrated platform for users and applications based on aggregation of heterogeneous and autonomous resources.

With the in-depth knowledge about concept of virtualization [6] there discussed the concepts of ISA, API and ABI interfaces in detail.

- ISA (Instruction Set Architecture) provides an interaction between application program and hardware.
- API (Application Programming Interface) provides interface between applications and
- ABI (Application Binary Interface) acts as boundary between software and hardware.
- It also discusses the compatibility issues of processors supporting ISA with some Operating systems.

Cloud computing has recently emerged as a new paradigm for hosting and delivering services over the Internet. There presents a survey on cloud computing, highlighting its key concepts, architectural principles, and state-of-the-art implementation as well as research challenges [7]. Here the research challenges are discussed such as automated service provisioning, Virtual machine, Server consolidation, Traffic management and Energy management and at last security which is one of the important issues to be solved.

A computer paradigm is shifted to remote data centers from past few years and the software and hardware services available on the basis of pay for use [11]. Data centre management faces the problem of power consumption. This survey paper shows the requirement of green computing and techniques to save the energy by different approaches.

Green computing is the environmentally sustainable to use of computers and related resources like -storage devices, networking and communication systems - efficiently and effectively with minimal or no impact on the environment [12].

The notion of Cloud computing has not only reshaped the field of distributed systems but also fundamentally changed how businesses utilize computing today. In this paper a new framework is presented that provides efficient green enhancements within a scalable Cloud computing architecture [13]. Using power-aware scheduling techniques, variable resource management, live migration, and a minimal virtual machine design, overall system efficiency will be vastly improved in a data center based Cloud with minimal performance overhead.

The pervasive use of cloud computing and the resulting rise in the number of data centers and hosting centers have brought forth many concerns including the electrical energy cost, peak power dissipation, cooling, carbon emission, etc [15]. With power consumption becoming an increasingly important issue for the operation and maintenance of the hosting centers, corporate and business owners are becoming increasingly concerned.

Cloud Computing is moving towards high performance computing usage of huge data center (DC) and huge cluster is increasing day by day and energy consumption by these DC and energy dissipation in environment by these DC is also rising day by day [18]. The authors proposed different ideas towards green cloud computing approach.

Virtualization Technology has been employed increasingly widely in modern data centers in order to improve its energy efficiency. In particular, the capability of virtual machine (VM) migration brings multiple benefits for such as resources (CPU, memory, et al.) distribution, energy aware consolidation [21]. Results show that the power overhead of migration is much less in the scenario of employing the strategy of consolidation than the regular deployment without using consolidation.

The survey in this paper shows that management techniques tailored to different types of servers and their associated workloads can provide substantial energy savings with little or no performance degradation [28].

Today's environmental challenge is global warming, which caused by emission of carbon. The energy crisis brings green computing and green computing needs algorithm and mechanism to be redesigned for energy efficiency [29]. This paper concluded that task consolidation particularly in clouds has become an important approach to streamline resources usage and in turn improve energy efficiency. The result in this study should not have only a direct impact on the reduction of electricity bills of cloud infrastructure providers, but also imply possible savings in other operational cost.

This paper introduces the relationship between domain scheduling in a virtual machine monitor (VMM) and I/O performance [30]. This paper is the first to study the impact of the VMM scheduler on performance using multiple guest domains concurrently running different types of applications. The cross product of scheduler configurations
and application type's offers insight into the key problems in VMM scheduling for I/O and motivates future innovation in this area.

3. Motivation for Research

The data centers consist of thousands of heterogeneous servers that consume lots of power and produce large amounts of heat [13]. Green computing, green IT or ICT Sustainability, is the study and practice of environmentally sustainable computing or IT.

There are two competing types of Green scheduling systems for Data centers: Power-aware and Thermal- aware Scheduling. In thermal-aware scheduling, jobs are scheduled in a manner that minimizes the overall data center temperature. The goal is not always to conserve the energy used to the servers, but instead to reduce the energy needed to operate the data center cooling systems.

In power-aware scheduling [33], jobs are scheduled to nodes in such a way to minimize the server's total power. The largest operating cost acquired in a Cloud data center is in operating the servers. So, concentration is put on power-aware scheduling in this research.

There are a number of implicit technologies, services, and infrastructure-level formation that make Cloud computing possible. One of the most important technologies is the use of virtualization. This is performed in the Cloud environment across a large set of servers using a Hypervisor or Virtual Machine Monitor (VMM) which lies in between the hardware and the Operating System (OS).

From here, one or more virtualized OSs can be started accordantly leading to one of the key advantages of Cloud computing. Nowadays with the advent of processors having multiple cores like Intel Dual Core and Core 2 Duo, allows for a consolidation of resources within any data center. It is the Cloud provider's job to fully utilize this capability to its maximum possibility while still maintaining a given QoS.

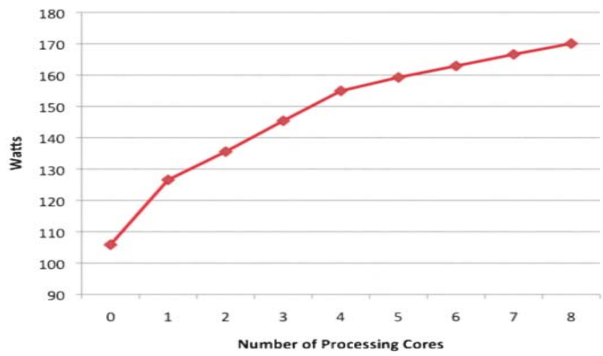

Figure 5: Power consumption curve of an Intel Core i7 920 CPU [13]

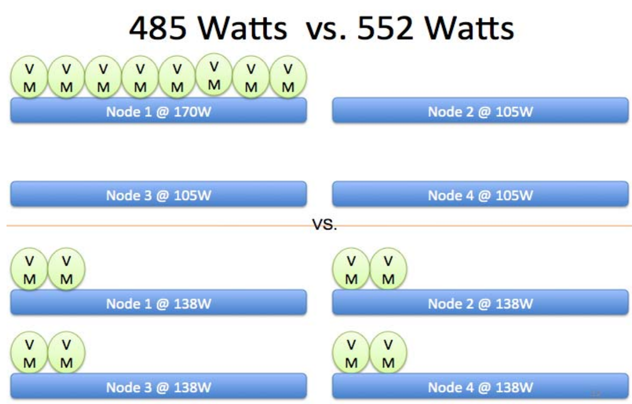

Figure 6: Illustration of power savings [13]

Figure 5 and 6 clarify the motivation behind power-aware VM scheduling. The Intel Core i7 920 CPU has 8 cores. VM can be build upon every single core, so this means we can have 8 VMs running on every core of Intel Core i7 920 CPU. This graph represents the recent research findings regarding watts of energy consumed verses the number of processing cores in use. The power consumption curve embellish that as the number of processing cores increases, the amount of energy used does not increase proportionally. In fact the change in power consumption decreases. When only one processing core is used, the change in power consumption meet with by using another processing core is over 20 watts. The change from 7 processing cores to all 8 processing cores results in an increase of only 3.5 watts. The impact of this finding is considerable [13].

4. Approaches to Green Computing

There are three approaches to green computing are discussed as:

a) Clients
End users interact with the clients to manage information related to the cloud [15].

b) Green Data Center
Datacenter is nothing but a collection of servers hosting different applications. A green data center is a data center which has efficient management of the system and associated system less power consumed environment. [11] [15].

c) Distributed Servers
Distributed servers are the parts of a cloud which are present throughout the Internet hosting different applications. [15].

5. Virtualization

Virtualization is a term that refers to the abstraction of computer resources. Virtualization means "something which isn't real", but gives all the facilities of a real. It is the software implementation of a computer which will execute different programs like a real machine [6] [11] [15].

<table>
<tr><td>APP1</td><td>APP2</td></tr>
<tr><td>OS1</td><td>OS2</td></tr>
<tr><td colspan="2">Virtualizing software</td></tr>
<tr><td colspan="2">Hardware</td></tr>
</table>

Figure 7: Virtual machine

At the very lowest layer is the actual hardware (Server). Above it is the virtualizing software Xen or VMware. The virtual machines capable of supporting a full operating system are known as system virtual machines. The hardware platform on which VM run is known as the host and the operating system running on the VM is known as the guest. The hardware has a specific (Instruction set architecture) ISA. So it can support only those operating systems which are compatible with that particular ISA.

6. Green Computing Architecture

The aim of this paper is to addresses the problem of enabling energy-efficiency, hence leading to Green Cloud computing data centers, to satisfy competing demand for computing services and save energy [19].

a) Consumers/Brokers: Cloud consumers or their brokers submit service requests from anywhere in the world to the Cloud.

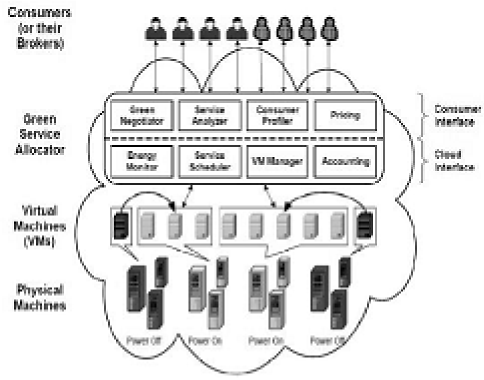

Figure 8: Green Cloud Architectural Elements [19]

b) Green Resource Allocator: Acts as the interface between the Cloud infrastructure and consumers. It requires the interaction of the following components to support energy-efficient resource management:

- Green Negotiator: Negotiates with the consumers/brokers to finalize the SLA with specified prices and penalties (for violations of SLA) between the Cloud provider and consumer depending on the consumer's QoS requirements and energy saving schemes.
- Service Analyzer: Interprets and analyses the service requirements of a submitted request before deciding whether to accept or reject it.
- Energy Monitor: Observes and determines which physical machines to power on/off.
- Service Scheduler: Assigns requests to VMs and also decides when VMs are to be added or removed to meet demand.
- VM Manager: Keeps track of the availability of VMs and their resource entitlements.

c) Virtual Machines different from physical machines

d) Physical Machines: The underlying physical computing servers provide hardware infrastructure for creating virtualized resources to meet service demands.

7. Data Centers Architecture

Two-tier data center architectures engage in the structure illustrated in Figure 9. In this architecture, computing Servers (S) physically arranged into racks form the tier-one network. At the tier-two network, Layer-3 (L3) switches provide full mesh connectivity using 10 GE links.

The two-tier architecture worked well for early data centers with a limited number of computing servers. Depending on the type of switches used in the access network, the two-tier data centers may support up to 5500 nodes [34].

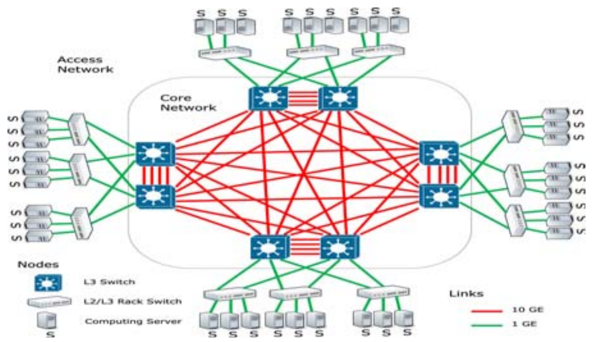

Figure 9: Two-tier data center architecture

The number of core switches and capacity of the core links defines the maximum network bandwidth allocated per computing server.

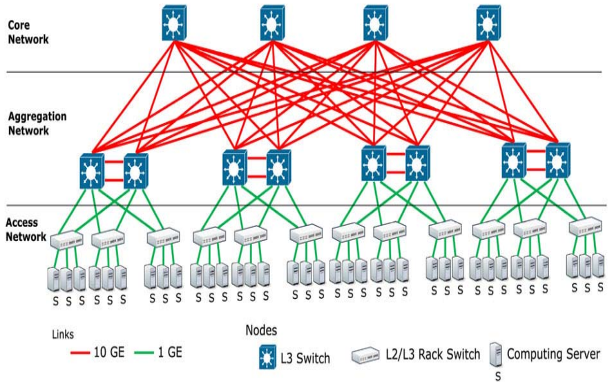

Figure 10: Three-tier data center architecture

Three-tier data center architectures are the most shared nowadays. They include: (a) access, (b) aggregation, and (c) core layers as presented in Figure 10.

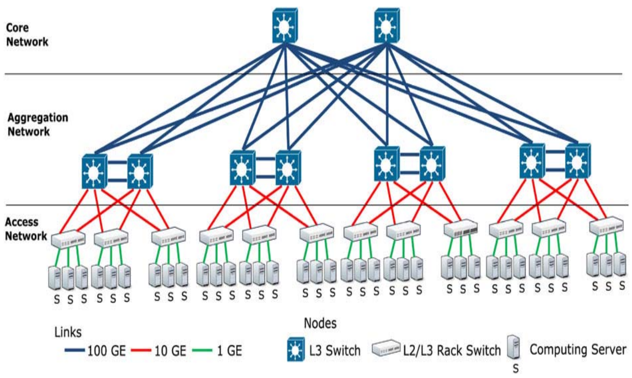

Figure 11: Three-tier high-speed data center architecture

The availability of the aggregation layer facilitates the increase in the number of server nodes (to over 10,000 servers) while keeping inexpensive Layer-2 (L2) switches in the access network, which provides a loop-free topology [34].

8. Live Migration

VM live migration is that in which a virtual machine is hand over from a physical server to another while ceaselessly running, without any evident effects from the point of view of end users [21].

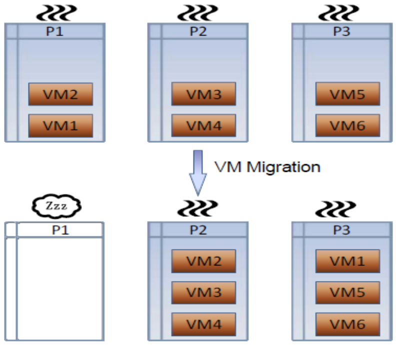

Figure 12: VM Migration [21]

Figure 12 consists of 6 VMs (VM1-VM6) running on three physical servers (P1-P3) with the VM migration technology. VM1 and VM2 consolidated on P2 and P3 respectively. And P1 is turned off, so the power consumption of the cluster is reduced [21].

9. Power Management in Data Centers

Power consumption of Data center is experiencing an alarming growth. Many organized operations have been made to improve the energy efficiency of data center, such as network power management, storage power management solutions etc. Generally, the modern approach to solve the problem is employing the virtualized technology, which enables multiple OS environments to coexist on the same physical computer, in strong isolation with each other. Consolidation is a well-known technique to dynamically reduce the number of nodes used within a running cluster by liberating nodes that are not needed by the current phase of the computation demonstrates the power consumption of data center reducing in the scenario of the employment of VM migration technology [21].

10. How proposed scenario works

Data centre energy costs are crucial come forth in cloud computing environment. Data centre energy costs in cloud computing will be lessened when virtualisation is used as contrary to physical resource deployment to book adequate to bestow all application requests. Nevertheless, in any case of the resource provisioning approximation, occasion remains in the way in which they are made attainable and workload is scheduled. Cost acquired at a server is a function of its hardware trait.

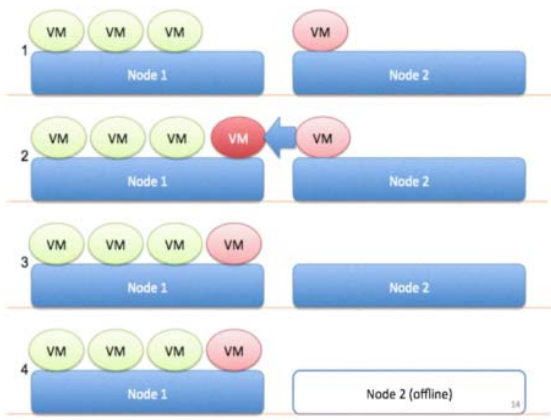

Figure 13: Illustration of power savings management [13]

The objective of this research work is therefore to pack workload into servers, selected as a function of their cost to operate, to achieve (or as close to) the utmost endorsed employment in a cost-efficient manner, avoiding occurrences where devices are under-utilized and management cost is acquired inefficiently. This work enhanced the existing work by introducing the dynamic wake up calls either to shut down the active servers or restart the passive server. The wakeup call will be initiated when the load is 80% and the shutdown will be initiated when we re-allocate load from one server to other. The overall attention is to decrease the response time of users which will be increased during wakeup time in existing research work. Figure 13 shows the power saving management. Therefore we can utilize the power consumption efficiently and also decrease the response time of existing work.

11. Gaps in Earlier Work

a) It has neglected the cost of swap in/ swap out.
b) Static wakeup calls are used which will result in poor response time.

12. Conclusion

This paper has evaluated the different techniques used for efficient energy consumption in cloud computing. Power consumption has found to be critical come forth in cloud environment because servers take much energy to accomplish their tasks or jobs. Cloud Computing go up with multiple servers so by using them efficiently may subdue the energy consumption problem. The survey has shown that the existing work on energy efficiency has neglected the use of dynamic wake up calls, thus will result in poor response time. In near future, we will extend this work by proposing a new energy efficient model which will utilize live migration and dynamic wake calls to enhance the results of cloud computing servers.

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Authors Profile

Gaganpreet Kaur received the B. Tech. degree in Computer Science from B.K.S.J Engineering College in 2012 and Pursuing M.Tech. (Final Year) in Software System from Guru Nanak Dev University, Amritsar respectively. Her home town is Amritsar. She got first prize in project presentation and educational skit in College Level and has good knowledge of LATEX, Ms Office and C#.net. Her area of interest is Emerging Computing technology.

Anil Kumar has done the M. Tech. in the field of Computer Science and he is an Assistant Professor in GNDU, Amritsar. His home town is Amritsar. His areas of interest are Computer Networks, Operating System, and Computer Architecture but specialized in Computer Networks fields.