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Greening the Cloud Computing

Deepak Prashant
B.tech (3rd year),
Computer Sci & Engg.
Dr. K. N. Modi University,
Rajasthan, India.
prashant.deepk@gmail.com

Abstract - *Cloud computing is emerging as a critical information communication technology to heavily impact our daily life in the future. It is an emerging trend in computing. This is happening at a time when there is increasing attention being paid to the need to manage energy consumption across the entire information and communication technology (ICT) sector. Data center energy has received much attention recently because there are very huge data centers used in industries today and environmentally, these systems can produce e-waste, harmful gases with heat. This paper focuses on different techniques to save over all energy consumption in the data centers, in the enterprises it is called as green cloud computers. Here i have explained and suggested the virtualization technique for saving energy, thus faciliating green cloud computing.*

Keywords - *Cloud computing, Green cloud computing, Private cloud, Public cloud, Virtualization, Hypervisor, Energy efficiency.*

1. Introduction

The depletion of fossil energy has become one of the major challenges for mankind to sustain the civilization. In addition, overindulgent energy consumption causes over emission of green-house gas, which, according to expert consensus [1], is a root cause for the current global warming. Seeking to replace fossil energy appears to be an attractive idea, but it may take a long time for the alternatives to attain wide deployment and economic efficiency. It is, therefore, imperative for mankind to seek *green technologies*, i.e., the technologies that can reduce energy consumption.

Among all industries, the information communication technology (ICT) industry is arguably responsible for a large portion of the world-wide growth in energy consumption. This is partly attributed to the rapidly increasing number of Internet and mobile ICT devices available across the globe. As Internet has penetrated into our daily lives, cloud computing has emerged as a new kind of "utility" that gets delivered through wired or wireless networks. And with the emergence of cloud computing world wide it has become our necessity to come up with *green computing*.

"***Green computing***" is the use of computing with environment responsibility. These practices include the energy efficient peripheral of the computing system and the energy efficient processors (CPU's), servers at various data centres or cloud centres. It also consists of reduced resources use and proper "e-waste" management.
The main goal of *Green Computing* is a more sustainable computing based on friendly solutions for the environment. It means limiting the environmental impact of industrial processes and pervasive technologies, but also reducing energy consumption [2].

Fig.-(a) A non-green system

Similarly, the term *"**Green cloud computing**"* gives environmentally beneficial, with cloud computing, programs, services run on our infrastructure or platform or we can say on our system, so there is no requirement for separate system for traffic management.
In Cloud infrastructures, data center energy consumption highly impacts the system capacity, efficiency and costs. The servers at data centers require a lot of energy and radiate a lot of heat. The heat and energy demands can even cause the hardware to melt or fry out, according to a report With more consumers and companies turning to the Cloud, it's important to consider how to make this run as smoothly as possible [3].
According to Urs Holzle (senior vice president at Google), companies are already taking steps in the right direction. Computers are becoming more efficient and, as companies move away from in-house servers, Cloud computing will become the green alternative of choice [4]. Best practices for enhancing energy efficiency cover several aspects, such as facility lighting or cooling system design and sleep scheduling have proven useful in reversing the trend of rising data center energy consumption. However, most Cloud providers still lack full and holistic solutions for reducing data center energy use [6].

2. Research Background

2.1 Cloud Computing

Cloud computing is a topic that is given increasing attention from IT managers in companies. The term "Cloud Computing" goes back to a collaboration announcement between Google and IBM

[8]. Before this time, various other technologies were discussed in the market which may be considered as predecessors of the term Cloud Computing like "Grid Computing" [9], "Computer in the Cloud" [10] or "Dreaming in the Cloud" [11].
A current definition of "Cloud Computing" is given by NIST: "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services)
that can be rapidly provisioned and released with minimal management effort or service provider interaction."[12].
Breaking this rather complex definition down we can describe Cloud Computing as the delivering of infrastructure, platform, and software in a service model based on a pay-per-use model provided to the customer [13].
When we talk about the architecture then Cloud computing architectures can be either public or private [15]. A private cloud is hosted within an enterprise, behind its firewall, and intended only to be used by that enterprise. In such cases, the enterprise invests in and manages its own cloud infrastructure, but gains benefits from pooling a smaller number of centrally maintained high-performance computing and storage resources instead of deploying large numbers of lower performance systems. Further benefits flow from the centralized maintenance of software packages, data backups, and balancing the volume of user demands across multiple servers or multiple data center sites. In contrast, a public cloud is hosted on the Internet and designed to be used by any user with an Internet connection to provide a similar range of capabilities and services. A number of organizations are already hosting and/or offering cloud computing services. Like for Examples include Google Docs [16], Amazon's Elastic Compute Cloud and Simple Storage services [17], Microsoft's Windows Azure Platform [18], IBM's Smart Business Services [19].
But while its financial benefits have been widely discussed, the shift in energy usage in a cloud computing model has received a lot of attention. Through the use of large shared servers and storage units, cloud computing can offer energy savings in the provision of computing and storage services, particularly if the end user migrates toward the use of a computer or a terminal of lower capability and lower energy consumption. At the same time, cloud computing leads to increases in network traffic and the associated network energy consumption.
The issue of energy consumption in information technology equipment has been receiving increasing attention in recent years and there is growing recognition of the need to manage energy consumption across the entire information and communications technology (ICT) sector [20]. Aggregate electricity use for servers doubled over the period 2000 to 2005 both in the U.S. and worldwide. Almost all of this growth was the result of growth in the number of volume servers. It is estimated that data centers accounted for approximately 1.2% of total United States electricity consumption in 2005 [21]. The transmission and switching networks in the Internet account for another 0.3% of total electricity consumption in broadband-enabled countries [22]. In addition to the obvious need to reduce the greenhouse impact of the ICT sector, this need to reduce energy consumption is also driven by the engineering challenges and cost of managing the power consumption of large data centers and associated cooling. Against this, cloud computing will involve increasing size and capacity of data centers and of networks, but if properly managed, cloud computing can potentially lead to overall energy savings.

2.2 Different techniques to manage power consumptions in data centers

The management of power consumption in data centers has led to a number of substantial improvements in energy efficiency. Cloud computing infrastructure is housed in data centers and has benefited significantly from these advances. One major step that can be taken in data centers for minimization of power consuption is to work toward better airflow management. According to Green House Data, part of that can be achieved by adjusting cabling on computers to ensure that they can exhaust heat properly. With this simple step, computers are less liable to overheat. This can help drive down energy costs.
Airflow can also come down to spacing of computers. According to IBM, each server rack should be arranged to create a cold aisle, where the fronts of racks can take in the cool air they need, and a hot aisle, where the racks exhaust the heated air. Care should be taken not to obstruct airflow at either end.
It can also boil down to floor tile placement. Perforated tiles should be placed in cold aisles, where air intake from below can rise into the front. Conversely, non-perforated tiles should be placed in the hot aisles, in order not to overtax air conditioning systems.
Data Trend says that one step which many companies take in setting up a system with better airflow is to locate farms in cooler climates. This drives down overall cooling costs by using natural environments to cool down the computers. After all, a city with a sweltering summer is going to drive up the cost of air conditioning for any business, let alone one as hot as a data center.
Improve Hardware Efficiency [7].
A *Stanford* report says that a key component to a greener data center is to make sure the hardware is performing up to its capacity [5]. Many server computers are performing at just 3–5 percent capacity, according to the report, while consolidation of computing resources can be a major factor in improving performance. Better software can also improve matters. These methods combined can put the capacity of the computing used at 30 to 80 percent. Use Renewable Sources of Energy Once efficiency is out of the way, the last and perhaps most important thing to tackle is the source of the energy itself. Apple has boasted a goal of 100 percent renewable energy company-wide, including data centers. As of 2012, the company claimed to be at 75 percent renewable sourced energy, often derived from solar power [7].
A data center in Maiden, North Carolina, is held up by the company as a shining example. The design and implementation of the center was built with energy efficiency in mind. And when it came time to power the center, a 100-acre, 20-megawatt solar array was built to power it all. All told, the company claims that the Maiden center runs on 100 percent renewable energy when the solar array and fuel cell technology are combined [7].
With the data center industry booming, as evidenced by a report in "The Washington Post" that a county in Virginia saw a three-fold increase since 2000. The total amount of data center space in the county has surpassed 4.5 million square feet, with another 200,000 square feet currently under construction. Another 1 million square feet of data center space is proposed for future development. The need to go green is becoming ever greater [14] .
According to Ars Technica, only 5 percent of current data centers are green, but companies like General Motors are taking the dive toward greener data centers.
Techniques such as, for example, sleep scheduling and server virtualization in cloud computing data centers, in which one machine acts as many servers at once, improve the energy efficiency of cloud computing.
Cloud computing allows us to run at high utilization of resources; you can use fewer number of computers this allows us to have higher utilization, saving on environment cost of building those computers. It is clear that with energy demand in computing is increasing and it gets shifted to cloud computing that is to become green. In this paper i am going to explore how the virtualisation technique can help to make the cloud system green and how the virtualization is the better solution for it. Due to increasing demand and development with the energy efficient and environment eco-friendly infrastructure is needed.

Virtualization refers to the abstraction of computer resources or the processes of two or more operating system on a single hardware machine. A cloud is a pool of virtualized computer resources. Virtualization consists of a system admin to combine physical systems into VM in maximally energy efficient manner. That is necessarily in green cloud computing point of view to less power

consumption. Virtualization assists in workload distribution and management. It gives significantly improved utilization.

2.3 Need of virtualization for green computing

Cloud computing cannot be always suitable for ecology [25]. The recent studies confirmed that rely on a server is generally more environmentally friendly, although care must be taken to a whole series of parameters to calculate the best real efficiency of the clouds [24]. According to a new research from Pike Research, the global market for green data centers will grow from $17.1 billion in 2012 to $45.4 billion by 2016 [24]. In other words, the data centers impact on real environment by producing heat. It is also important to keep in mind that a data center has a more environmental impact than a system. The research was based on setups those include virtualization and without virtualization. It is found that on-site server with no virtualization will emit about 46kg of CO_2 per year. The figure will touch 2kg if a person using a public cloud conforming to best practices. If data is stored on the public cloud whose servers are not that efficient, those servers are not well used and use electricity from higher carbon-emitting sources. Thus, there could be some practices by which servers can be run with greener solutions. Also, studies also proved that cloud systems are more energy efficient and carbon efficient than that of an ordinary system [25].

About cloud computing (fig.-1), it consists of a concept of use of virtualization. And thus, virtualization is critical to cloud computing. It simplifies the delivery of services by providing a platform for optimizing complex IT resources in a scalable manner. That makes cloud computing so *cost effective*. In cloud computing it needs to support many different operating environments, to manage the various aspects of virtualization in cloud computing most companies use *hypervisors.*

A *hypervisor,* also called a *virtual machine manager (VMM),* is a program that allows multiple operating systems to share a single hardware host. Each operating system appears to have the host's processor, memory, and other resources all to itself. However, the hypervisor is actually controlling the host processor and resources, allocating what is needed to each operating system in turn and making sure that the guest operating systems (called virtual machines) cannot disrupt each other [26].

The hypervisors can support different operating system environment hence, the hypervisor becomes an ideal delivery mechanism by allowing you to show the same application on lots of different systems. Because hypervisors can load multiple operating systems, they are a very practical way of getting things virtualized quickly and efficiently.

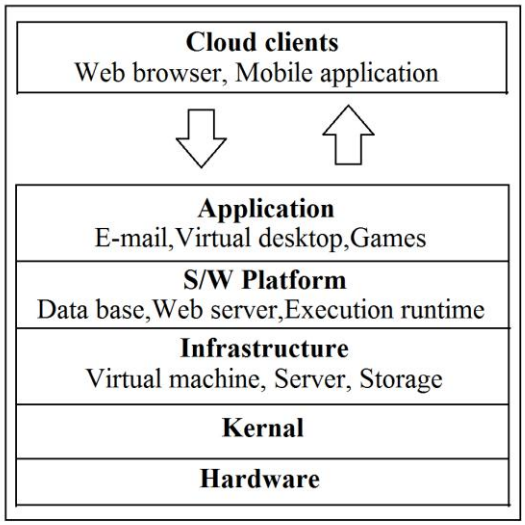

Fig.-(b) Cloud computing: basic model

2.4 Virtualization based on hypervisor

Virtualization makes easing the administrative burden of deploying, managing, delivering resources, and providing the ability for end users to request and use virtualized resources.

The VM pool consists of the number of OS environment and as system boots, the hypervisor is available for controlling of system. It is analogous to VMM. Some of these VMs are given privileges and those can manage the virtualization platform and hosted Virtual Machines (VM). In this architecture, the privileged partitions view and control the Virtual Machines. This approach establishes the most controllable and secured virtualization and also it can prevent various misbalancing and security concerns for the VM pool. The hypervisor is a software component which controls access to the physical hardware. (Fig.-b) It may run on top of a host operating system, allowing other operating systems to run within this host OS, and so on the same physical hardware. The latter inherently gives lower performance, since it has to go through more layers of software to access the physical resources.

Cloud Computing may look like Virtualization because it appears that your application is running on a virtual server detached from any connection to a single physical host. However, Cloud Computing can be better described as a service where Virtualization is part of a physical infrastructure. Cloud Computing builds on top of a virtualized infrastructure using standardization and automated delivery to provide service management. Thus, it makes monitoring of the virtualized resources and the deployment of these resources possible. Virtualization is a necessary for adopting a cloud computing infrastructure. [27]

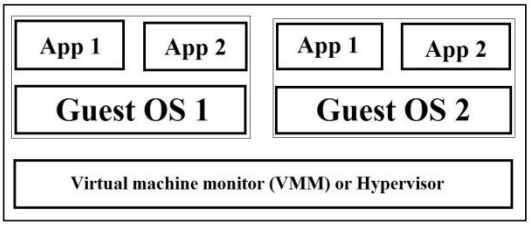

Fig.- (c) Virtualization with hypervisor OS

3. Discussion on how virtualization works as in the green cloud computing

Let's discuss about how virtualization makes cloud green or eco-friendly. We know, the data center consumes the power as huge as that can be used to power thousands of homes. The environmentalists and computer scientists are working on reducing the huge amount of power used and make data centers more energy-efficient than they currently are. The virtualization can be the solution for it. It can be used to reduce power consumption by data centers. The main purpose of the virtualization is that to make the most efficient use of available system resources, including energy. A data center, installing virtual infrastructure allows several operating systems and applications to run on a lesser number of servers, it can help to reduce the overall energy used for the data center and the energy consumed for its cooling. Once the number of servers is reduced, it also means that data center can reduce the building size as well. Some of the advantages of Virtualization which directly impacts efficiency and contributes to the environment include: Workload balancing across servers, Resource allocation and sharing are better monitored and managed and the Server utilization rates can be increased up to *80%* as compared to initial *10-15%.* The energy saved per server would be near about *7000 KWH* per year.[23] It means that there would be large saving of energy, hence virtualization is the best practice for

Green Cloud Computing especially in the developing countries like India. Where the power saving is the today's most basic need**.**

4. Conclusion

The main aim of this paper was to discuss about the cloud computing and its impacts in the environmental point of view. Here i have explored the concept of Green Cloud Computing. Then i have explored cloud computing architecture along with the different techniques to manage power consumption to go green. And then i have explored the need of virtualization for green computing along with the different model (basic and virtualization) of Cloud computing and the Concept of Virtualization based on *hypervisor*. Then i have discussed that how the virtualization technique is the best solution for making the green cloud computing and how the use of virtualization can be the most beneficial which includes load balancing, resource management, server utilization and the most importantly, power savings. That makes the ordinary data centre Cloud Computing as, the *Green Cloud Computing.*

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