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A Survey on Green Computing Techniques

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***Abstract*— Today computational power grows rapidly therefore we have 'Cloud computing' concept to fulfil this need. But, in Cloud computing high performance cloud servers are used for advance computational needs. Due to these computational unit executions, a large amount of power consumed, on the other hand the effect is that some harmful gases are also released in a similar amount of energy. Green Computing is the concept which is trying to confine this procedure by inventing new methods that would work efficiently while consuming less energy and making less population. This paper focuses on Green computing techniques, in order to achieve low power consumptions.**

Keywords —Green Computing, Data Center, Virtualization

I. INTRODUCTION

Cloud computing refers to as the delivery of computing resources over the Internet. Instead of keeping data on your own hard drive or updating applications for your needs, you use a service over the Internet, at another location, to store your information or use its applications. Cloud computing consist hierarchy of concepts, which comprises several models. The first model is the Service Model [1] which further includes three models namely – software as a service, platform as a service and infrastructure as a service. Second is the Deployment model [1] which further comprises of public cloud, private cloud, community cloud and hybrid cloud.

According to National Institute of Standards and Technology (NIST) – "the major objective of cloud computing is to maximize the shared resources and at the same time the disadvantage is its high infrastructure cost and unnecessary power consumption."

Global warming has been a big concern of late, with high power consumption and CO2 emission.

With the continuously increasing popularity and usage of cloud computing, high power consumed and harmful gasses released by data centers. Cloud uses thousands of data centers to processes user queries and to run these data centers bulk amount of power is used for cooling and other processes. This power consumption increases gradually every year and green computing playing a helpful role to curb these issues.

Green Computing [2] is defined in various contexts, environmentally, socially and politically with respect to effective and efficient use of energy to achieve competitive advantage in terms of an energy-cost saving strategy, and reduction to carbon emission/footprints, recyclability, biodegradability, and minimal impact to the environment. Green computing represents environmentally responsible way to reduce power and environmental e-waste. Main goals of green computing are to reduce the use of toxic and hazards materials and improve the energy efficiency, recycling of factory waste. Such practice includes the efficient implementation of server and peripherals as well as reduces the power consumption.

A. Advantages of Green Computing :

1. Reduced energy usage from green computing techniques translates into lower carbon dioxide emissions, stemming from a reduction in the fossil fuel used in power plants and transportation.
2. Conserving resources means less energy is required to produce, use, and dispose of products.
3. Saving energy and resources saves money.
4. Green computing even includes changing government policy to encourage recycling and lowering energy use by individuals and businesses.
5. Reduce the risk existing in the laptops such as chemical known to cause cancer, nerve damage and immune reactions in humans.
6.

B. Green Computing Approaches :

Green computing can be achieved by different approaches. Some approaches illustrate as:

1) *Product longevity:* Gartner maintains that the PC manufacturing process accounts for 70% of the natural resources used in the life cycle of a PC. Therefore, the biggest contribution to green computing usually is to prolong the equipment's lifetime. Another report from Gartner recommends to "Looking for product longevity, including upgradability and modularity. "For instance, manufacturing a new PC makes a far bigger ecological footprint than manufacturing a new RAM module to upgrade an existing one.
2) *Data center design:* Data center facilities are heavy consumers of energy. The U.S. Department of Energy estimates that data center facilities consume up to 100 to 200 times more energy than standard office buildings. According to the U.S. Department of Energy, Information technology (IT) systems, Environmental conditions, Air management, Cooling systems and Electrical systems are the primary areas on which to focus energy efficient data center design best practices.
3) *Software and deployment optimization:* It includes algorithmic efficiency, resource allocation, terminal servers and virtualization. The efficiency of algorithms has an impact on the amount of

computer resources required for any given computing function and there are many efficiency trade-offs in writing programs. Allocating resources according to the energy can be saved. With virtualization, a system administrator could combine several physical systems into virtual machines on one single, powerful system, thereby unplugging the original hardware and reducing power and cooling consumption. Virtualization can assist in distributing work so that servers are either busy or put in a low-power sleep state. Terminal servers have also been used in green computing. When using the system, users at a terminal connect to a central server; all of the actual computing is done on the server, but the end user experiences the operating system on the terminal. These can be combined with thin clients, who use up to 1/8 the amount of energy of a normal workstation, resulting in a decrease of energy costs and consumption.

4) *Power management:* The Advanced Configuration and Power Interface (ACPI), an open industry standard, allows an operating system to directly control the power-saving aspects of its underlying hardware. This allows a system to automatically turn off components such as monitors and hard drives after set periods of inactivity. In addition, a system may hibernate, when most components (including the CPU and the system RAM) are turned off. ACPI is a successor to an earlier Intel-Microsoft standard called Advanced Power Management, which allows a computer's BIOS to control power management functions.[citation needed]Some programs allow the user to manually adjust the voltages supplied to the CPU, which reduces both the amount of heat produced and electricity consumed. This process is called undervolting. Some CPUs can automatically undervolt the processor, depending on the workload; this technology is called "SpeedStep" on Intel processors.
5) *Materials recycling:* Recycling computing equipment can keep harmful materials such as lead, mercury, and hexavalent chromium out of landfills, and can also replace equipment that otherwise would need to be manufactured, saving further energy and emissions.
6) *Telecommuting:* Teleconferencing and telepresence technologies are often implemented in green computing initiatives. The advantages are many; increased worker satisfaction, reduction of greenhouse gas emissions related to travel, and increased profit margins as a result of lower overhead costs for office space, heat, lighting, etc.
7) *Telecommunication network devices energy indices:* The energy consumption of information and communication technologies (ICTs) is today significant even when compared with other industries. Recently some study tried to identify the key energy indices that allow a relevant comparison between different devices (network elements). This analysis was focus on how to optimize device and network consumption for carrier telecommunication by itself. The target was to allow an immediate perception of the relationship between the network technology and the environmental impact.

C. *Green Computing Techniques to Manage Power in Computing System-*

These techniques can be classified at different levels:
1) Hardware and Firmware Level
2) Operating System Level
3) Virtualization Level
4) Data Center Level

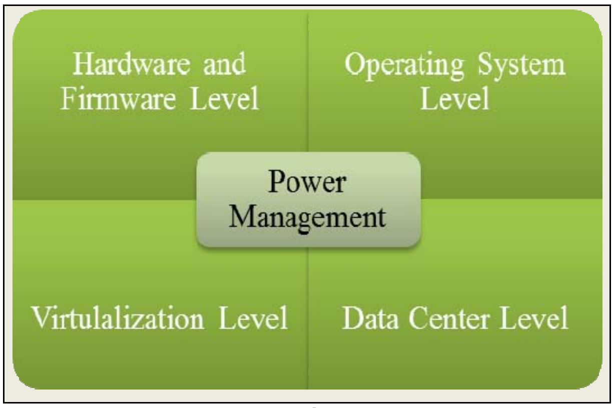

Fig.1 Power Management Techniques in Green Computing

Hardware and Firmware level techniques are applied at the manufacturing time of a machine. These techniques contain all the optimization methods that are applied at the time of designing at the logic, circuit, architectural and system levels. Operating System level techniques include methods which take care about programs at operator level.

Virtualization level techniques used the concept of Virtual Machines (VMs) to manage power. In this number of VMs are created on a physical server, so that reduce the amount of hardware in use and improve the utilization of resources.

Data Center level techniques are applied at data centers and include methods which are used to manage workload across physical nodes in data centers

In this paper we are focusing on data center level techniques for managing power in computing system.

D. *Data Center Level Techniques-*

Data Centers are those which contain a computer system and its associated system such as telecommunication and data storage systems. It also requires backup power supply, some cooling system and security system. A green data center has an efficient management of the system and associated system less power consumed environment.

Data center level approaches based on workload consolidation across physical nodes in data centers. The workload can be represented by incoming requests for online servers or web applications, or virtual machines. The goal is to allocate request/virtual machines to the minimal

amount of physical resources and turn off or put in sleep state the idle resources. The problem of the allocation is twofold: firstly, it is necessary to allocate new requests; secondly, the performance of existing applications / VMs should be continuously monitored and if required the allocation should be adapted to achieve the best possible power-performance trade-off regarding to specified QoS.
Data Center Level approaches further divided into two parts-

Non-Virtualized Systems: Non-virtualized systems are those in which single operating system owns all hardware resources.

Virtualized Systems: Virtualized systems are those in which multiple operating systems share hardware resources.

We further survey on virtualized systems for managing power in data centers.

E. ***Virtualization-***

Virtualization is the abstraction of an OS and applications running on it from the hardware. Physical resources can be split into a number of logical slices called Virtual Machines(VMs).Each VM can accommodate an individual OS creating for the user a view of a dedicated physical resource and ensuring performance and failure isolation between VMs sharing a single physical machine. The virtualization layer lies between the hardware and OS and; therefore, a Virtual Machine Monitor (VMM) tacks control over resources and has to be involved in the system's power management in order to provide efficient operation.

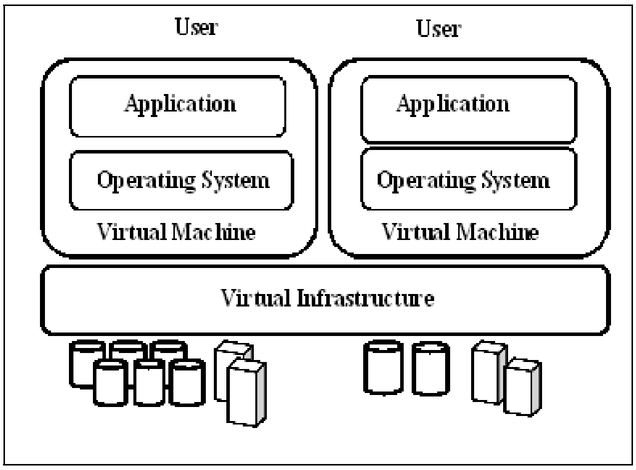

Fig. 2 Virtualization

II. RELATED WORK

Liang-The Lee et al [4] presented dynamic resource management with energy saving mechanism and gives a method of dynamic voltage scaling for dynamic adjustment of resources by inspecting CPU utilization in cloud computing environment. In this method the voltage of the idle or light loaded computer is reduced and heavy loaded works is migrated to those machines which are lighter loading.
Energy-aware resource management for a HPC data center is critical. Takouna, I. et al [5] presented power-aware multicore scheduling and FindHostForVm to select which host has minimum increasing power consumption to assign a VM. The FindHostForVm, however, is similar to the PABFD's [6] except that they concern memory usage in a period of estimated runtime for estimating host energy. The work also presented a method to select optimal operating frequency for a (DVFS-enabled) host and configure the number of virtual cores for VMs. Nguyen Quang-Hung et al also presented EPOBF's FindHostForVm which is different from the previous works in a way that the EPOBF's FindHostForVm chooses which host has the highest value of ratio of total maximum of MIPS (in all cores) to the host's maximum value of power consumption[7].
There is another way to reduce power consumption. Chia-Tien Dan Lo et al [9] presented algorithmic approach to reduce power consumption. They told about Fine-Grained Green Computing and Coarse-Grained Green Computing. Fine-grained green computing refers to running a program efficiently and effectively via a subtle power control on each computing resources as CPU, memory, registers, peripherals, clock management, and power supply while coarse grained green computing in which the program's execution is in a full power mode disregarding to whether the program is using a memory banks or I/O peripherals.
FeiFei Chen et al [10] presented a new energy consumption model and associated analysis tool for Cloud computing environments. They measure energy consumption in Cloud environments based on different runtime tasks. Empirical analysis of the correlation of energy consumption and Cloud data and computational tasks, as well as system performance, will be investigated based on energy consumption model and analysis tool.
George Perreas et al [11] proposed a centralized monitoring entity that attempts to reduce power consumption in Internet Data Centers (IDCs) by employing live Virtual Machine (VM) migrations between blade servers. To perform live VM migrations, usage statistics collected by servers are evaluated and the servers that may be offloaded are selected. VMs that belong to the servers that may be offloaded are scattered to other active servers provided that the user-perceived performance is sustained. Overall, jobs submitted by users should be consolidated to as few servers as possible and the servers that host no job can be put in stand-by or hibernate mode, thus achieving an overall power reduction. Data center management authorities may take advantage of such a monitoring entity in order to decrease energy consumption attributed to computing, storage and networking elements of data centers.

TABLE I
ANALYSIS OF TECHNIQUES FOR MANAGING POWER AND ENERGY IN VIRTUALIZED ENVIRONMENT

S.no	Title	Purpose	Method used	Advantages	Disadvantages
(1)	Energy based Efficient Resource Scheduling: A Step Towards Green Computing.	(a)Architectural principles for energy efficient management of clouds (b) Energy efficient resource allocation strategies and scheduling algorithm considering quality of service outlooks.	Energy based efficient resource scheduling algorithm.	Performs better in all the three cases, i.e., low, high and random resource usage.	Considered only energy as quality of service parameter.
(2)	A Dynamic Resource Management with Energy Saving Mechanism for Supporting Cloud Computing.	To manage dynamic resources with energy saving mechanism by measuring CPU utilization.	Dynamic Voltage Frequency Scaling (DVFS) for dynamically adjustment of voltage and frequency of the processor in execution time.	In this proposed work with saving energy also CPU utilization is performed.	When workload is heavy, real time migration is performed for achieving more effective usage of resources but a lot of migration increases energy consumption.
(3)	Efficient Resource Management for Cloud Computing Environment.	To improve the efficiency of the system in a data center with minimal performance overhead.	Power based VM scheduling algorithm for scheduling virtual machines.	Power consumption is decreased by using power based scheduling, which distributes the VMs with the intended to fully utilize all processing cores within each node.	Considered only energy as QoS parameter.
(4)	Energy Efficient Allocation of Virtual Machines in High Performance Computing Cloud.	Minimizing total energy consumption of physical machines in high performance cloud and satisfying QoS.	Energy-aware and Performance-per-watt oriented Best-fit (EPOBF) algorithm.	Used heterogeneous physical machines and saved more energy as compare to previous work done.	It saved only 35% of energy.
(5)	Reducing Electricity and Network Cost for Online Service Providers in Geographically located Internet Data Centers.	An optimization load dispatching model to minimize the overall cost for online service providers (OSPs).	Adaptive optimization algorithm.	This considered total cost of network as compared to previous work and also calculate total cost using carbon emission.	It also considered minimum no. of QoS parameters.

III. CONCLUSIONS

In this paper, we analyze many techniques for managing power and energy in computing system. We have surveyed different approaches used for data center to manage efficiency of energy using virtualization. The work presents in this paper indicate the ever increasing interest of researchers in the area of green computing. Many green computing methods for energy efficiency are proposed by researchers however, green computing technology needs to be further researched because of high power consumption in data centers. We conclude power management techniques in a virtualized environment by analyzing the existing work in table1.

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