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Comparative Analysis upon Energy Efficiency between Cloud Computing and Green Computing

Er. Sukhdeep Kaur*
Rayat and Bahra University, India

Er. Ritika
Rayat and Bahra University, India

Er. Meena Rani
Rayat and Bahra University, India

Abstract--In general, cloud computing focus on the data computing efficiency; green cloud computing is a new thinking which is based on cloud computing architecture and focuses on the energy efficiency of device and computing. Although it is widely claimed that cloud computing is "green" because of its better energy efficiency. Green computing whose goals are to reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote the recyclability or biodegradability of defunct products and factory waste . Virtualization, Green Data Centre, Cloud computing, grid computing, Power optimization are the technologies of green computing. Virtualization is the use of software to simulate hardware. In the data centre stand alone server system replaced with virtual server that run as software on a small number of larger computer via a virtualized server we can efficiently use computer resources. This paper is concluded with a discussion of advancements identified in energy-efficient computing.

Keywords --Energy efficiency, power utilization, Computer Virtualization, green data centre, power optimization

I. INTRODUCTION

Green computing and green technology refers to the environmentally responsible use of computers and any other technology related resources. Green computing includes the implementation of best practices, such as energy efficiency central processing units (CPUs), peripherals and servers. In addition green technology aims to reduce resource consumption and improve the disposal of electronic waste (e-waste). Green computing is a large and

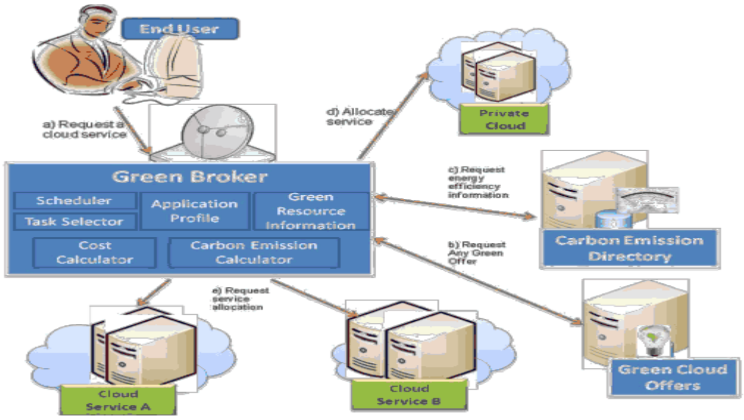

Fig.1 Green Cloud Computing

Increasing area. The need for saving energy has become a top priority in almost all segments of the IT market.[1] The need for energy efficiency has become a critical factor in the design of high performance computing. The increasing availability of high-speed Internet and corporate IP connections is enabling the delivery of new network-based services. While Internet-based mail services have been operating for many years, service offerings have recently expanded to include network-based storage and network-based computing. These new services are being offered both to corporate and individual end users. Services of this type have been generically called cloud computing services .The cloud computing service model involves the provision, by a service provider, of large pools of high-performance computing resources and high-capacity storage devices that are shared among end users as required. There are many cloud service models, but generally, end users subscribing to the service have their data hosted by the service, and have computing resources allocated on demand from the pool. The service provider's offering may also extend to the software applications required by the end user[2]. To be successful, the cloud service model also requires a high-speed network to provide connection between the end user and the service provider's infrastructure.
Cloud computing potentially offers an overall financial benefit, in that end users share a large, centrally managed pool of storage and computing resources, rather than owning and managing their own systems. Often using existing data centres as a basis, cloud service providers invest in the necessary infrastructure and management.

II. GREEN COMPUTING TECHNIQUES FOR ENERGY EFFICIENCY

Understanding the ways in which power consumption impacts the “greenness” of any technology, and specifically computing technology, is an essential step toward reducing this consumption and educating others. This section describes the various specific techniques that can be used to reduce power consumption.

1) *Turn Off Equipment When Not In Use :* Powering down equipment is the simplest, most effective and most obvious way to reduce computing power consumption. This convenience is costly since the simple act of powering off a computing device will significantly reduce its power consumption, although it is important to note that many devices may still consume a small amount of power or “phantom load.”
2) *Computer Power Savings Modes* :Management of power consumption is a standard, yet often overlooked, feature of most computers and operating systems on the market today. The barrier to wider adoption is that many find power savings modes to be inconvenient as there can be a brief delay in exiting a power saving mode back to normal use. Resistance is understandable, although with careful system configuration and gradual acclimation to a different way of working, this hesitancy can be overcome.
3) *Monitor Sleep Mode :*Allowing the monitor to fall asleep after idling for some time period is another easily employed method for improving energy efficiency. When a monitor falls asleep or enters a “stand by” mode, it enters a low power consumption state. The monitor screen will be blank, with no light emitting from it. For example, a Dell 20” widescreen LCD uses approximately 55 watts of power when it is on. In sleep mode, the power use drops to around 3 watts, resulting in significant energy savings.
4) *Hard Disk Sleep Mode :*A computer can place its hard disk drives in a low power sleep mode when they are idle. Hard disk drives on desktop computers can use 10 watts or more when in use while notebook computer drives use less but energy savings have the benefit of extending battery charge life. Operating system settings again manage this mode automatically once configured. This setting provides a small savings and is minimally intrusive, with more significant savings possible using system standby mode[3].
5) *System Standby Mode :*System standby is one of the most effective power saving features. After a preset idling period, a computer will shutdown most of its components significantly reducing power use. Volatile memory remains active so that whatever the user was working on will still be there when the computer wakes up from standby mode. A desktop computer that uses more than 100 watts idling can use as little as 5 watts when in standby mode, using one twentieth of the electricity it used when idling.
6) *Hibernate Mode :*The hibernate mode goes one step further than standby mode by completely powering off the computer. Invoking the hibernate mode causes the memory state to be saved onto the hard disk before powering down. When coming out of hibernate mode, the computer restores the memory state, returning the computer to its pre-hibernate state. A desktop computer will consume approximately 3 watts in hibernate mode vs. 5 watts for standby.

III. ENERGY EFFICIENCY TECHNIQUES FOR CLOUD COMPUTING

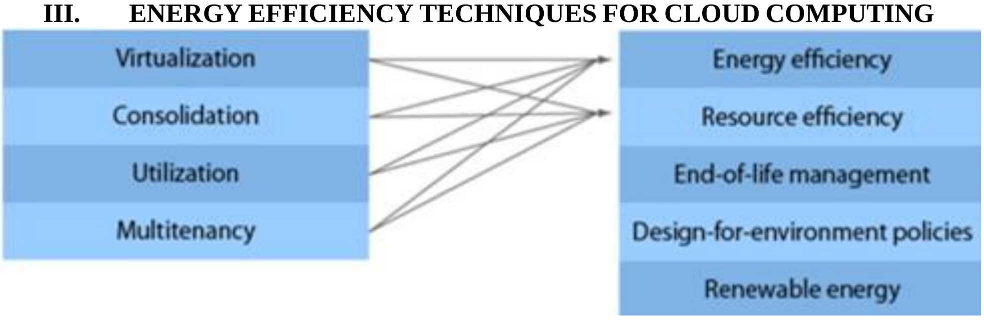

Fig. 2 Energy efficiency techniques

1) *Applications*: SaaS model has changed the way applications and software are distributed and used. More and more companies are switching to SaaS Clouds to minimize their IT cost. Thus, it has become very important to address the energy efficiency at application level itself. However, this layer has received very little attraction since many applications are already on use and most of the new applications are mostly upgraded version of or developed using previously implemented tools. To achieve energy efficiency at application level, SaaS providers should pay attention in deploying software on right kind of infrastructure which can execute the software most efficiently[4]. This necessitates the research and analysis of trade-off between performance and energy consumption due to execution of software on multiple platforms and hardware. In addition, the energy consumption at the compiler level and code level should be considered by software developers in the design of their future application implementations using various energy-efficient techniques proposed in the literature.
2) *Cloud Software Stack: Virtualization and Provisioning* : In the Cloud stack, most works in the literature address the challenges at the IaaS provider level where research focus is on scheduling and resource management to reduce the amount of active resources executing the workload of user applications. The consolidation of VMs, VM migration, scheduling, demand projection, heat management and temperature-aware allocation, and load balancing are used as basic techniques for minimizing power consumption. As discussed in previous section, virtualization plays an important role in these techniques due to its several features such as consolidation, live migration, and performance isolation[4]. Consolidation helps in managing the trade-off between performance, resource utilization,

and energy consumption. Similarly, VM migration allows flexible and dynamic resource management while facilitating fault management and lower maintenance cost. Due to multiple levels of abstractions, it is really hard to maintain deployment data of each virtual machine within a Cloud datacenter. Thus, various indirect load estimation techniques are used for consolidation of VMs.

3) *Datacenter level: Cooling, Hardware, Network, and Storage* : First level is the smart construction of the datacenter and choosing of its location. There are two major factors in that one is energy supply and other is energy efficiency of equipments. Hence, the datacenters are being constructed in such a way that electricity can be generated using renewable sources such as sun and wind. Currently the datacenter location is decided based on their geographical features; climate, fibre-optic connectivity and access to a plentiful supply of affordable energy. Since main concern of Cloud providers is business, energy source is also seen mostly in terms of cost not carbon emissions. Another area of concern within a datacenter is its cooling system that contributes to almost 1/3 of total energy consumption. two types of approaches are used: air and water based cooling systems. In both approaches, it is necessary that they directly cool the hot equipment rather than entire room area. Thus newer energy efficient cooling systems are proposed based on liquid cooling, nano fluid- cooling systems, and in- server, in-rack, and in-row cooling by companies such as SprayCool. Other than that, the outside temperature/climate can have direct impact on the energy requirement of cooling system. Some systems have been constructed where external cool air is used to remove heat from the datacenter

4) *Monitoring/Metering* : To measure the unified efficiency of a datacenter and improve its' performance per-watt, the Green Grid has proposed two specific metrics known as the Power Usage Effectiveness (PUE) and Datacenter Infrastructure Efficiency (DciE) .

PUE = Total Facility Power/IT Equipment Power

DciE = 1/PUE = IT Equipment Power/Total Facility Power x 100%

The Total Facility Power is defined as the power measured at the utility meter that is dedicated solely to the datacenter power[5]. The IT Equipment Power is defined as the power consumed in the management, processing, and storage or routing of data within the datacenter.

5) *Network Infrastructure* : At network level, the energy efficiency is achieved either at the node level (i.e. network interface card) or at the infrastructure level (i.e. switches and routers). The energy efficiency issues in networking is usually referred to as "green networking", which relates to embedding energy-awareness in the design, in the devices and in the protocols of networks. There are four classes of solutions offered in literature, namely resource consolidation, virtualization, selective connectedness, and proportional computing. Resource consolidation helps in regrouping the under-utilized devices to reduce the global consumption. Similar to consolidation, selective connectedness of devices consists of distributed mechanisms which allow the single pieces of equipment to go idle for some time, as transparently as possible from the rest of the networked devices. The difference between resource consolidation and selective connectedness is that the consolidation applies to resources that are shared within the network infrastructure while selective connectedness allows turning off unused resources at the edge of the network. Virtualization as discussed before allows more than one service to operate on the same piece of hardware, thus improving the hardware utilization. Proportional computing can be applied to a system as a whole, to network protocols, as well as to individual devices and components. Dynamic Voltage Scaling and Adaptive Link Rate are typical examples of proportional computing. Dynamic Voltage Scaling reduces the energy state of the CPU as a function of a system load, while Adaptive Link Rate applies a similar concept to network interfaces, reducing their capacity, and thus their consumption, as a function of the link load.

IV. ENERGY CONSUMPTION ANALYSIS

To calculate the amount of energy consumed by data centers, two metrics were established by Green –cloud grid, an international consortium [6]. The metrics are Power Usage Effectiveness (PUE) and Data Centre Infrastructure Efficiency (DCiE) as defined below

PUI=Total Facility power/IT Equipment Power

DCiE=1/PUE=(IT Equipment Power/Total Facility Power) *100%

The IT equipment power is the load delivered to all computing hardware resources, while the total facility power includes other energy facilities, specifically, the energy consumed by everything that supports IT equipment load.

In cloud infrastructure, a node refers to general multicore server along with its parallel processing units, network topology, power supply unit and storage capacity. The overall energy consumption of a cloud environment can be classified as follows:

$$E_{cloud} = E_{Node} + E_{Switch} + E_{Storage} + E_{Ohters}$$

Consumption of energy in a cloud environment having n number of nodes and m number of switching elements can be expressed as:

$$E_{Cloud} = n(E_{CPU} + E_{Memory} + E_{Disk} + E_{Mainbosrd} + E_{mainboard} + E_{Nic}) + m(E_{Chassis} + E_{Linecards} + E_{Ports}) + (E_{NASServer} + E_{StrorageController} + E_{DiskArray}) + E_{Others}$$

V. CONCLUSION

In this paper we have investigated the energy efficiency techniques in cloud and green computing. It has been shown that there are few major components of cloud architecture which are responsible for high amount of power dissipation in cloud. The possible ways to meet each sector for designing an energy efficiency model of green & cloud computing has been studied. This survey discussed techniques for improving the energy efficiency of computing. For computing resources, the solutions work at different levels, from individual nodes to entire infrastructures where they take advantage of recent advanced functionalities such as virtualization. One of the main leverages to reduce the electric bill and the carbon footprint of IT infrastructure is to increase the energy awareness of users and providers.

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