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Green Computing: An Era of Energy Saving Computing of Cloud Resources

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Abstract: Cloud computing is a widely acceptable computing environment, and its services are also widely available. But the consumption of energy is one of the major issues of cloud computing as a green computing. Because many electronic resources like processing devices, storage devices in both client and server site and network computing devices like switches, routers are the main elements of energy consumption in cloud and during computation power are also required to cool the IT load in cloud computing. So due to the high consumption, cloud resources define the high energy cost during the service activities of cloud computing and contribute more carbon emissions to the atmosphere. These two issues inspired the cloud companies to develop such renewable cloud sustainability regulations to control the energy cost and the rate of CO_2 emission. The main purpose of this paper is to develop a green computing environment through saving the energy of cloud resources using the specific approach of identifying the requirement of computing resources during the computation of cloud services. Only required computing resources remain ON (working state), and the rest become OFF (sleep/hibernate state) to reduce the energy uses in the cloud data centers. This approach will be more efficient than other available approaches based on cloud service scheduling or migration and virtualization of services in the cloud network. It reduces the cloud data center's energy usages by applying a power management scheme (ON/OFF) on computing resources. The proposed approach helps to convert the cloud computing in green computing through identifying an appropriate number of cloud computing resources like processing nodes, servers, disks and switches/routers during any service computation on cloud to handle the energy-saving or environmental impact.

Index Terms: Computation Resource; Cloud Services; Green Computing; Energy Consumption; Sleep-Mode.

1. Introduction

Cloud computing is a common computing environment that provides a variety of on-demand technologies and services. Cloud Computing offers cloud users with hardware, applications, and apps. Cloud computing incorporates computing resources such as equipment, applications and networking that can be transmitted over the Web as a service [1]. Systems such as Open Models for cloud delivery distribute vast resources and services in cloud infrastructure for customers. To create a private network, a private model is used. It's only within the context of a company. The Group model is used to distribute cloud user's network tools. Hybrid architecture is a combination of two or more cloud activities with internal and external resource management [2].

At the same period as on-demand demand for software storage business often raises the largest growth in Internet usage, the cloud computing service on-demand is raised. The cloud service company constructs a large cloud data center which has high resource availability, providing a high power cost for cloud computing, thus requiring high energy consumption [3]. Power can be reduced by reducing the amount of energy that meets the demands for workload; thus, redundant resources are shut down or put in low power mode while the workload is smaller. Likewise, when the workload rises, additional resources are moved to high electricity [4].

Although we may be mindful of the use of the cloud computing tools, there are many challenges and incredible energy consumption, production of carbon dioxide and related price problems. As a result, cloud service providers are

becoming extremely damaged for the operation and maintenance of cloud resources [5]. Data clients use all the outlets provided by data operators. Nonetheless, software computing services tend to consume electrical power within the range of many Megawatts [6].

Recent developments in processing usable resource technologies have rendered energy consumption more difficult to reach the actual level. Nevertheless, because the amount of energy concerned with the assistance of electronic sources is first and foremost influenced by their mode of use, it remains a critical challenge for technological tools. In many words, a larger amount of energy use is measured by efficient use of resources for use of useful resources. In addition to scripting, virtualization and reduction, it includes a variety of power-saving techniques [7].

The computing services are the foundation of the cloud. The use of capital at all levels is not restricted to the increase in computing and data market. Assets are exchanged with multiple customers to provide dynamism allocated and reassigned to the multi-tenant model, which has distinct organizational and technological assets in accordance with the consumer call [8].

Cloud requires thousands of energy to provide the services to the customer and to run various categories, consuming massive power, and in recent years it has been cold. Different hardware innovations, such as virtualization, containers and computational development, are possible, such as machine efficient algorithms to reduce energy consumption [9]. Through maximizing the elimination of energy consumption and increasing the efficiency of cooling and electrical power in the Cloud data center infrastructure you are able to achieve the intensity green cloud. According [10] the cloud resources consumed near about 1.1%–1.5% of the world's energy in the last few years. It is also expected that after completion of the year 2020 the total energy consumption of cloud resources will be more than 140 TH.

Green cloud computing is designed to reduce energy usage not just by allowing the economic operation and use of computing resources. The most important objective of novice cloud computing is the control of energy-conscious data, economic policies and algorithms for virtualization, resource claim, allocation of resources, employment and activities in the field, as well as many land and environmentally friendly conventional technologies[11] for the next millennium. The transfer of services is a useful way for handling cloud resources in particular in the short and long-term use of cloud resources. The efficient green use of cloud assets to reduce the number of active cloud resources and to put unused resources directly into the power saving mode or perhaps to switch off some idle resources [12].

2.   Related Review

The distribution of resources is one of the challenges in the cloud environment, since the user may access services at any moment from anywhere. The key challenge in a cloud is for users who have dynamic requests for resources to allocate resources in support of their application patterns. The unstable and complex requests will operate on cloud services throughout the network. The software is incredibly important, because the program correlated with central processor, memory, storage and database calculation is generally called the IT tool at intervals in cloud environments [14]. The problem of allocation of resources is rather costly and calls for expectations and a variety of system management configuration processes for job servers, a collection of service level arrangement for consolidating activities and a decrease in the loss of electricity and expense of use of services. The difficulty of resource allotment entails the appropriate allocation and economic use of available resources for the use of the square resource allotment measure in order to boot strictly due to workloads which lead to completely extraordinary demands for resources on behalf of cloud providers [15].

In this regard the energy efficient approach in cloud computing is more essential to handle the energy saving issue or environmental impact. Table 1 describes the review of some approaches related to energy efficient computing in cloud.

Table 1. Review of Energy Efficient Computing Approaches in Cloud

Ref. No	Year & Publication	Key Idea	Findings
16	2013, IEEE Transactions on Cloud Computing vol. 1(Issue 2), Pg. 215–228.	VM Consolidation based on sleep mode of PMs.	In a selection of physical devices is define the limited allocation of resources and avoid the wasting of energy through transferred them into the sleep mode until a VM assigned to them. Using the smallest number of PMs Fitting enough to operate a variety of VMs in a highly dynamic environment, while no prior VMs usage data are operating throughout the network, despite violation of SLA and reduction of efficiency. In it two different algorithms are working in such manner that each VM should be paired with only one request and the victim ship field will share among the allocation of requests.
17	2016, *Cluster Computing,* vol. *19* (Issue 2), Pg. 679–698. DOI:10.1007/s10586-016-0566-9	Task Scheduling based on minimum number of migrations.	For routing all queries to the Information Center over the smallest number of PMs, the resource allocation algorithm system is gone. In the case of any VM release, the application consolidation algorithms are then dead to insure that machine resources are used constantly in a cost efficient manner. At the same time, the minimization of the number of migrations is another major objective, while migration takes time and has the importance, diagrammatic in the completion times of work that affects the system performance.

18	2016, *Computing*, vol. *98* (Issue 7), Pg. 751–774. DOI: 10.1007/s00607-014-0407-8	Resource Allocation based on Power Management through disk back Up.	Cloud information center power consumption, large-scale, company, disk-based backup storage. Power management of the storage devices mainly focuses on the regulation of disk power. Actually, backups and depositors are worthy of being used as storage devices. The number of disks will enhance the function of the disk region where the main power shoppers are situated. The separate drives are not used for power-up yet. Deposit systems are used to position, clean, and recover details that change multiple drives within the system.
19	2015, International Journal of Applied Engineering Research (2015), vol. 10 (Issue 5), Pg. 0973–4562.	VM assignment under traffic condition in cloud infrastructure.	The cloud network infrastructure met the network connections, which could be additionally disrupted and applied to complex programs within the network due to the increasing functionality and knowledge needs of product apps. Today, a move towards cloud computing contributes to increased network traffic and congestion. Congestion may not necessarily be foreseen in a very cloud infrastructure in several cases.
20	2012, *IEEE Communications Surveys and Tutorials*, vol. *14* (Issue 1), Pg. 3–20.	Virtualization of application and services in cloud network.	When network enhancement isn't properly enforced, cloud computing will actually increase the value of contact. When cloud applications have a cloud-based response unit, end-to-end network access is vital for preventing apps from temporarily ordering, corrupting information or forestalling staff at remote locations. Additional information measurement is required to cover application areas, such as virtualized server apps and software-as-a-services running within the cloud network.
21	2015, IEEE Transactions on Cloud Computing	Request Allocation under overloaded and under loaded Cloud conditions.	In the middle layer of the cloud environment between the cloud servers and thus the consumer demands that delegate processes for several clouds at peak and under load conditions. Since the task is carried out by the consumer, such criteria are defined with every user operation as well as time information, time information process, time limit, requirements for input-output. The distribution of capital is carried out consecutively and every system at intervals should be dead. If one system becomes dead at a similar time, the process migrates from one cloud to another.

3.   Green Environment of Cloud Computing

The energy consumption as well as utilization of cloud resources are closely related to the power wattage function that is seen below:

$$P_N = E_N / T \tag{1}$$

$$E_N = P_N * T \tag{2}$$

Where P_N is used to measure the power, T measured the time amount and E_N measured the consumed energy. The disparity between energy and power is extremely important, since reducing power usage just takes time to decrease energy consumption [22].

The green cloud ecosystems have built themselves to save energy consumed by cloud services. The cloud services contain various processing node, server nodes, network devices and topology, storage devices and other electrical equipment that take part to calculate the total power consumption and it calculate by the formula of energy given as below:

$$E_{GCR} = E_{PN} + E_{SN} + E_{NET} + E_{SD} + E_{OE} \tag{3}$$

E_{GCR}-*Energy of green cloud resources*, E_{PN}-*Energy of processing nodes*, E_{SN}-*Energy of server nodes*, E_{NET}-*Energy of network devices like routers/switches*, E_{SD}-*Energy of storage devices (Disk/Racks) and E_{OE}-Energy of other electrical equipment*. For the physical resources the total energy will also calculated in the following two terms, first E_{STATIC} define the maximum energy consumption of any server in spite of working or idle VMs. And second $E_{DYNAMIC}$ define the energy consumption of all working VMs at any instance. Assume n number of VMs are used at any instance for a cloud service than

$$TE_{PR} = E_{STATIC} + E_{DYNAMIC} = E_{STATIC} + \sum_{i=1}^{n} E_{VM\ i} \tag{4}$$

Every VM have also different components like CPU, RAM, I/O etc. so E_{VMi} *can also be describe as sum of energy consumed by the components of VM* as:-

$$E_{VMi} = E_{VMi}^{CPU} + E_{VMi}^{RAM} + E_{VMi}^{I/O} \tag{5}$$

$E_{VMi}^{I/O}$ includes the common energy cost of all those devices that involve in I/O operation such as storage on disk and data transfers on network.

Cloud services such as execution and storage define its energy consumption in terms of the workload of resources like CPU, disk and network interfaces and it will reduce through the policy of ON and OFF the cloud resources. The cloud network replaces the measuring device with a complex reconfiguration that once activated adjusts the storage operation. The inactive shift to the energy saving mode like sleep and hibernate modes is use to reduces the consumption of energy in cloud [23].

4. Energy Saving Algorithm

The energy consumption is one of the biggest problems in the cloud computing world. The algorithm for energy saving saved the energy from the estimation of idle cloud resources at any instance. Energy savings means reducing the energy consumption thus producing a similar result.

The algorithm of energy saving starts with determining the task and the scale of the work, how often the different capabilities of cloud infrastructure services can be used. Each resource has its own workspace. The algorithm of energy savings can resolve very difficult questions such as the allocation of resources within the cloud system. It identifies the unaccredited resource and disabled the route. But if the scale of the input product approaches the existing available option then in the next cycle the unused resource is switched on.

Step-1 Initially identifying all the available resources in cloud at any instance.
Step-2 Calculate the processing time of each available resource ($\sum_{i=1}^{n} PT_{VM\,i}$)
Step-3 Calculate the size processing time of each arrival request in cloud at any instance ($\sum_{i=1}^{n} R_i$)
Step-4 If ($\sum_{i=1}^{n} R_i < \sum_{i=1}^{n} PT_{VM\,i}$)
Step-5 Allocate the all arrival task to required resources.
Step-6 Unallocated resources are moved to the idle or energy savings mode like sleep/hibernate.
Step-7 Repeat step 1 to step 6 for all arrival at any instance

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5. Comparative Analysis

Energy capacity of cloud resources can estimated in Watts per hour and it is observe that if all cloud resources are in ON stage than consumption of energy during cloud services will be maximum as shown in Table 2.

Table 2. Energy Consumption of Cloud Resources

Type of Resource	Total Resources	Energy Consumption (Approximate)		
		Per Hour	Per Day	Per Year
Router / Switch	30	20 * 30 = 600 Watts	600 * 24 = 14400 Watts	14400 * 365 = 5256 KW
Processing Node	50	100 * 50 = 5000 Watts	5000 * 24 = 120000 Watts	120000 * 365 = 43800 KW
Server	10	850 * 10 = 8500 Watts	8500 * 24 = 204000 Watts	204000 * 365 = 74460 KW
Disk Storage (Rack)	10	1200 * 10 = 12000 Watts	12000 * 24 = 288000 Watts	288000 * 365 = 105120 KW

But the consumption of energy by cloud resources is calculated in green environment i.e. energy saving mode (ON/OFF stage) then it is observed that energy consumption is reduce according to Table 3.

Table 3. Energy Consumption of Cloud Resources under Green Environment

Type of Resource	Total Resources	No. of Resource (Switched ON)	Energy Consumption (ON Resources) (Per Hour)	Energy Saving (OFF Resources) (Per Hour)	Energy Saving Ratio (%)
Router / Switch	30	15	15* 20 = 300 Watts	15* 20 = 300 Watts	50
Processing Node	50	35	35* 100 = 3500 Watts	15* 100 = 1500 Watts	30
Server	10	6	6* 850 = 5100 Watts	4* 850 = 3400 Watts	40
Disk Storage (Rack)	10	6	6* 1200 = 7200 Watts	4* 1200 = 4800 Watts	40

An energy-efficient control of cloud resources in green environment defines the consumption of energy in three modes i.e. working (ON), idle and sleeping (OFF). Where maximum energy saving is achieved in sleep (OFF) mode of non-useable resources at any instance. Energy consumption will also reduce at some certain level if any resource can remain in idle mode if the resource does not function for a short period of time rather than move to sleep mode instantly, when the resource is empty. Now the principal approach to reduce the energy consumption in cloud to map the requests on the minimum number of physical resources and to turn off idle nodes. So the adoption of active set of servers will be reconfigured dynamically by cloud resources. Energy uses will be minimized as converting the unused resources into energy saving mode i.e. working (ON), idle and sleeping (OFF).

Utilization chart of energy (power) consumption of cloud resources for any instance service time under cloud computing and green cloud environment is shown in Figures 1 and 2 respectively.
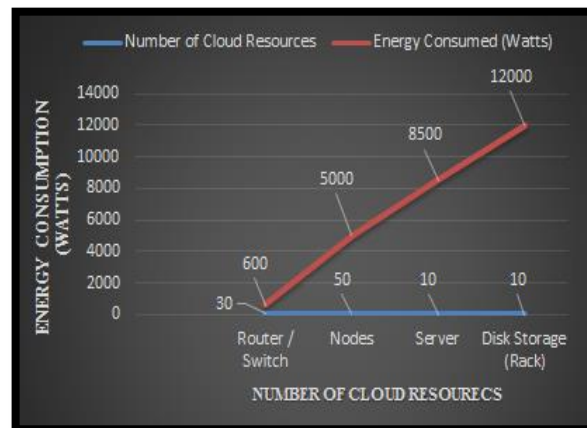

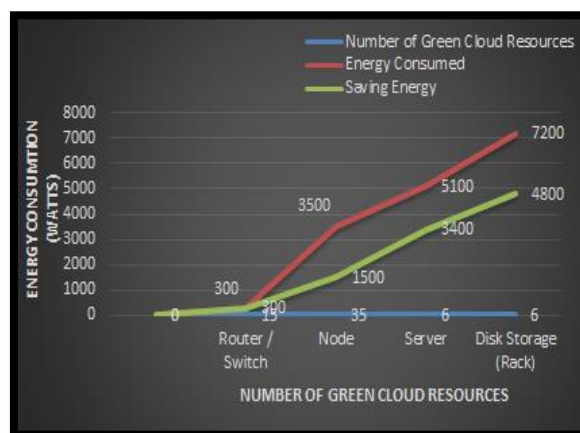Fig.1. Energy Consumption (per hour) in Cloud Computing (All Resources are ON)

Fig.2. Energy Consumption (per hour) in Green Cloud Computing (Some Resources are OFF)

This indicates that the consumption of energy will effected with a high and low use of resources for computing services in cloud. The index of efficient uses of resources, showing the average usage ratio of all resources for any instance of services. It indicated that, energy consumption will be effective of that resource(s) whose utilization ratio is also effective.

6. Conclusion and Future Aspect

In the Green Cloud environment, the most challenging task at present is to turn energy efficiency into energy sustainability. The simulation of energy saving approach shows that the amount of cloud resources are minimized at some certain level as per the requirement of services at any instance and thus the usage of energy will also reduce. The Proposed approach of putting ON only the required resources and rest become OFF regarding the saving of energy during service convert the cloud computing into green computing. Here we have seen that if any resource scheduling allow to OFF near about half cloud resources then we get 40 to 50 percent reduction in the consumption of the energy. So that this reduction of energy usage affected the service cost in cloud computing as the reduction of electricity charges and eco-environment through less omit of CO_2.

In future, if we able to predict the service request in advance then the appropriate number of computing resources that can accommodate predicted amount of service requests can be activated and Cloud systems will save more energy by preventing excessive activation of computing resources. Due to this service prediction approach we will able to define the state (ON/OFF) of the computing resources in advance. So that the energy comsumed in converting the state of computing resources from ON to OFF during computation will save.

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