Energy Efficiency in Cloud Data Centres: A Novel Approach towards Green Cloud Computing

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Abstract

Cloud Computing plays an imperative role in the evolution of IT resources, but at the same line it is also contributing emission of CO_2 in the air. With the increment in environmental impacts around the world, energy efficiency is one of the important considerations in data centres. 2021 was the Earth's fifth hottest year (figure 1) announced by European Scientist **Carlo Buontempo**, **director of the Copernicus Climate Change Service**. According to Copernicus, the mean temperature globally last year was 1.1 to 1.2° Celsius higher than they were before and pumping large quantities of Carbon dioxide into the air. The increasing level of greenhouse gases in the atmosphere is causing long- lasting changes in the global Climate. To overcome this problem, we need Green Cloud Computing for IT resources.

In this paper, we proposed an algorithm on the basis of certain existing algorithm limitations, which will help to minimize the environmental impact. We further analyse the efficiency of our algorithm and optimized its performance.

Keywords: Carbon Dioxide Emission, Green Cloud Computing, Energy Efficiency, Data Centres, Hypervisor, Virtualization, Cloud Computing.

Introduction

Cloud Computing is one of the growing technology now a days. Cloud computing is fully dependent on Virtual Machines (VM's) for each task whether storing data, fetching data, or searching data and so on. VM make the system easy to host the computation and applications for large number of Cloud users by giving illusion of a single system. Large amount of Data is stored in the Cloud Data Centre so as the result lots of power is consuming at the large scale and it is very necessary to balance the power of these Cloud Data Centre. As a survey, Data Centre consumes 0.5% of electricity consumption all over the globe. In 2009, the total energy consumption for Cloud Data Centre and their cooling units were at 1.2% the total US energy consumption and it increases every year. High power consumption leads to large amount of CO_2 emission. CO_2 is the main concern to convert computing into Green Cloud so there is the need of better Cloud which leads to the energy efficiency in Virtual Machines load balancing. Countless methods can be applied to attain high performance of computing like improvement of application algorithm, energy efficiency hardware, Dynamic Voltage frequency scaling, Virtualization of computing resources etc. Life of a computer system is

directly related to its Operating units. More the CPU will utilize less the energy will consume.

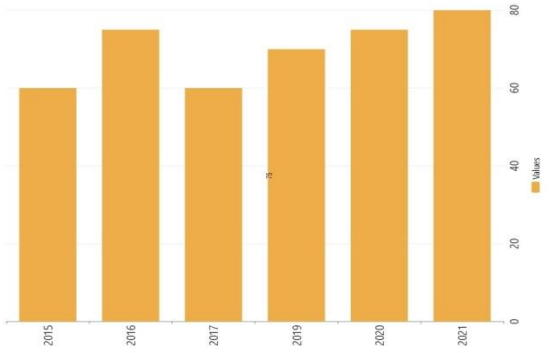


Figure 1: Graph of hottest year

Cloud Computing is growing rapidly as everything is converting into digitalization in contrast with increasing number of users day by day.

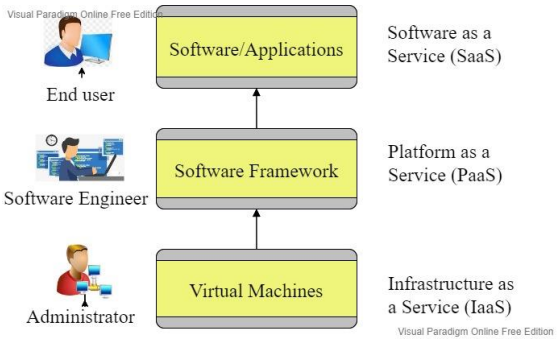


Figure 2: Service Model

What is Cloud Computing?

Cloud is a commodious technique where users have a convenient, on demand network access to a shared pool of resources, such as storage, applications, and servers over the internet. Cloud computing is heavily rely on virtualization. Everything that are accessing from the internet is not in our on premises but exists on somewhere else or some other computer called server computer and those services are enabled by virtualization.

Though service oriented architecture advocates “Everything as a service” (EaaS or XaaS). As per NIST, Cloud Computing offers three service models and four Deployment models. Service models are Infrastructure as a service (IaaS), Platform as a service (PaaS), Software as a service (SaaS) and Deployment models are Public Cloud, Private Cloud, Hybrid Cloud and Community Cloud.

According to the survey conducted in 2018, there are approximately 3.6 billion consumer Cloud users. According to Right Scale’s annual State of the Cloud Report for 2019, 91% of businesses used public cloud while 72% used private cloud and around 69% uses hybrid cloud (combination of public and private cloud).

What is Green Computing?

Large amount of data is stored in Cloud Data Centres which emits lots of energy from the Data Centres and so it becomes very important to balance the power of these cloud data centres. Another aspect is that number of data centres is constructing in large amount but there is less number of users. Hence CPU is not utilizing properly and as a result the CO_2 is emitting in higher amount in the atmosphere and will increase double in another year’s.

The Cloud Computing technique has made outstanding remark across the world. CO_2 is the major concern to convert computing into green Cloud. High efficiency is the vital concern of Data Centres to maximize the energy efficiency without harming the environment so the concept of Green Cloud Computing has been performed.

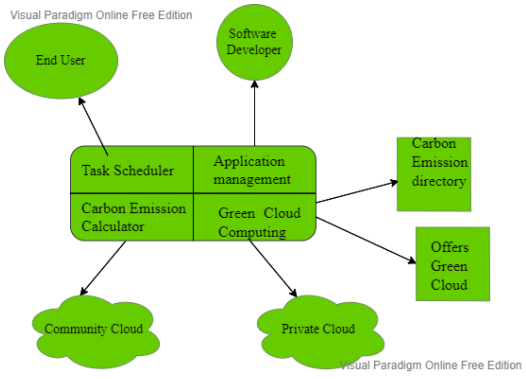


Figure 3: Green Cloud Computing

Study of previous energy aware scheduling

In 2010, Andrew J. Younge developed a framework that provides efficient green enhancement within a scalable cloud computing architecture. In this paper the author defined that using power aware scheduling techniques, resource management, live migration and a minimal virtual machine design, overall system efficiency will be greatly improved in a data centres.

Junyang proposed an Operating system level technique that performs thermal aware job scheduling to reduce the number of thermal trace passes. Applying the parallel computing paradigm in data centres, cloud computing has become popular over last few years, cloud computing is basically a pool of computer resources to provide the computing in terms of utilities. The destination of data centres worldwide requires the energy that shows a large operational cost for cloud data centres. Energy consumption is 10% of current data centre expanses and will rise to 50% in the same year. For classical data centre range pf $2 to $5 million per year. In the expenses for heat and requires accompany cooling system. Such heat and temperature is affecting on hardware performance and it is violating the SLA (Service Level Agreement) with the customer.

In 2017, R.K Jena discovered that the energy consumption and make span associated with the resources allocated should be taken into account. This paper focuses on task scheduling using Clonal Selection Algorithm (TSCSA) to optimize energy and processing time. The result obtained by TSCSA was simulated by an open source cloud platform (CloudSim).

In 2018, Anup Gade proposed that the idle terminal in data centres and heat dissipated by these devices makes significant contribution in making atmospheric changes. There is number of algorithms available through which effective load balancing and power saving is possible. Migration of Virtual Machines (VM) so as to reduce requirement of physical machines is taken into under consideration so that overall power consumption will also be reduced. Energy consolidation is also an area where light need to be thrown. It's time to implement a combinatorial approach where effective changes at server level and client level can make the significant difference.

In 2018, Kavita.A Sultan proposed that energy consumption in cloud computing occur due to the unreasonable way in which tasks are scheduled. So energy aware task scheduling is a major concern in cloud computing as energy consumption results into significant waste of energy, reduce the profit margin and also high carbon emissions which is not environmentally sustainable. Hence, energy efficient task scheduling solutions are required to attain variable resource management, Cache memory environmental protection with minimal performance overhead. This paper Cloud computing provides a comprehensive overview of the energy efficient techniques and Energy efficiency approaches and proposes the energy aware resource utilization framework to Resource utilization control traffic in cloud networks and overloads.

In 2019, J. M. T. I. Jayalath presented that Cloud computing itself is a much greener alternative to individual data centres with lesser number of servers being used and cloud data centres being far more efficient

than those of traditional thereby reducing the carbon impact. Nonetheless, it cannot be neglected the fact that the data centres utilized by the cloud vendors are still a major source of carbon emissions due to the dirty energy usage. Therefore, the discussion of the paper is based on how green the foremost cloud providers are and the implementations of green IT attributes in the cloud infrastructure.

In 2020, Fathi E. ABD EL-SAMIE frame work is based on both the request scheduling and server's consolidation approach that rather than depending only on one approach as in the existing related works. The EEH framework sorts the customers' requests (tasks) according to the time and power needs before performing the scheduling. It has a scheduling algorithm that considers power consumption when taking its scheduling decisions. It also has a consolidation algorithm that determines the under loaded servers to be slept or hibernated, the overloaded servers, the virtual machines to be migrated and the servers that will receive migrated virtual machines. In addition, the EEH framework includes a migration algorithm for transferring migrated virtual machines to new servers. Results of simulation experiments indicate the superiority of the EEH framework to the utilization of one approach only to reduce power consumption in terms of power usage effectiveness (PUE), data centre energy productivity (DCEP), average execution time, throughput and cost saving.

In 2021, Prerana Chaithra presented that Cloud computing gives power to compute and provides service to the users around the whole world. Thus providing customers with higher performance which is of lower cost compared to dedicated high -performance computing machines. IT sectors consume large amount of power and energy, resulting as a main source of Carbon dioxide emission. To overcome this, we need Green Cloud Computing for IT resources to be energy efficient and operating at cheaper cost. In order to reach optimal standards for green cloud computing. The efficiency of the power of Cloud must be very meticulously analysed. Cloud computing is a better alternative being greener than individual data centres by using less number of servers. Data centres using cloud are far better than the traditional ones. Thereby the impact of carbon is reduced.

In this work, we have proposed our algorithm based on energy aware temperature control system, based on energy aware resource management. Scheduling technique based on our previous survey, we will implement our work that will demonstrate a simple optimization of data centre's architecture and energy aware scheduling of the work load may lead to significant energy savings.

Proposed Algorithm

A technique of cloud computing is let program run in Virtual Machine. That is rather than giving them (client) the actual hardware of the machine directly, they interact with the machine via a kind of gatekeeper that manages interaction between the application and the hardware.

Cloud Computing plays a crucial role in today's scenario. It is one of the developing computing techniques which are the future of high-performance super computers. There might be a time when everyone would rely on cloud networks and cloud network should perform in such a way that it would fulfil all the user's requirements. Virtualization in cloud computing is the most important part in the cloud data centres to maximize the energy efficiency in cloud data centres.

Virtualization allows sharing single physical resources among multiple customers and organizations. Migration of VM takes a crucial part in job scheduling. When one machine gets overloaded with the task then VM would have to migrate from one machine to another machine in such a way that the physical machine should not be affected.

In other terms, stand-by-servers is being attached to the physical machine in order to reduce load. For example, There are 'n' jobs so single machine cannot able to perform the entire task individually and efficiently. For efficient work stand-by-server is attached to the physical server to reduce the load balancing. The important point in VM consolidation is to turn on the Hibernate mode and so system does not emits energy as much. VM consolidation is the process to relocate the virtual machine without affecting the physical server.

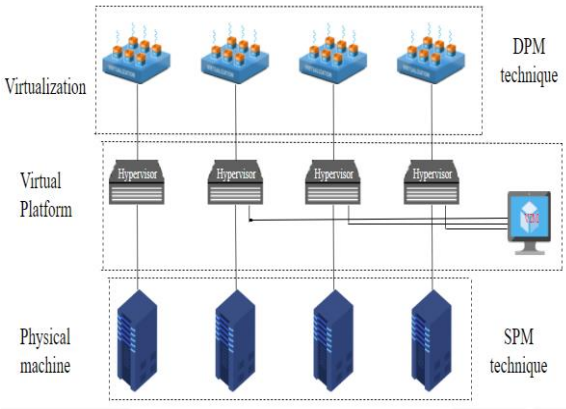
Brown power plants like Peepal tree, Banyan tree, Ashok tree, money plant should be grown near the data centres because these trees consume more amount of Carbon Dioxide gas that is very helpful for the environment.

Deletion of spam mails: According to research by McAfee, more than 78% of all incoming emails are spam mails and require the use of 33bn kilowatt-hours and causing around 20 million tonnes of CO_2 per year that is equivalent of the electricity used by 2.1m US homes. The major role that could be done by client's side is that we could ask client's to delete unwanted or unusable spam mails by adding simple banner in mail containing "Please delete unwanted spam mails", that would be very helpful in order to sustain the green cloud.

One major related work to convert in green cloud is 'Threading'. A thread is a single consecutive flow of control within a process. While multithreading allows multiple threads created within a same process and executing concurrently with sharing of resources. Thread is somewhat to not create a multiple instances of a single process rather it is better to create multiple threads within a process so that each small or similar tasks can be done by each thread. Hence create copy of instances instead of copying of processes. Threading is very efficient way to achieve green computing. The main cause of energy emission is that CPU is not utilizing 100% but due to the concept of multithreading, CPU will utilize efficiently. So software should be made with the concept of multithreading where multiple instances/thread will be created and shares the same resources, and the CPU will not sit idle. Hence the CPU will utilize nearly 100% or improved system throughput. Also synchronization is very necessary for smooth communication between threads. Thread synchronization allows the thread to access the object when multiple threads are trying to access the same object. Synchronization helps to avoid the blockage of object and allows the normal flow among threads. Energy saving technique in computing equipment can be achieved by Dynamic Power Management (DPM). DPM are more energy saving technique in large machines like servers machine, supercomputers which require higher computing powers. DPM is very efficient to implement in software or on network layer projects like to design an algorithm and prototype. Due to this, one can achieve high bandwidth, low latency communication between separate tasks.

Static Power Management (SPM) is more energy saving technique in hardware level. So designing hardware with respect to SPM is more efficient in order to reduce load in computer systems. Use of Solid States Drives (SSD) instead of Hard Disk Drives (HDD) as SSD is best for storing operating systems, gaming apps, and frequently used files. SSD is more durable

and takes less memory as compare to the HDD.



Conclusion

The energy efficiency of computing equipment's plays an imperative role in the overall energy consumption of cloud data centre. In this paper we have observed CPU utilization, Energy emission from Spam mails, VM migration, SPM/DPM, SSD/HDD, threading, time required to complete allotted tasks, where as there are still lot of work to do with respect to the data centres. In this work we have proposed our idea based on power consumption on software and hardware level. Based on previous approach, we will implement our work that will demonstrate the optimization on cloud data centres through which the computing can be truly converted into green cloud.

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