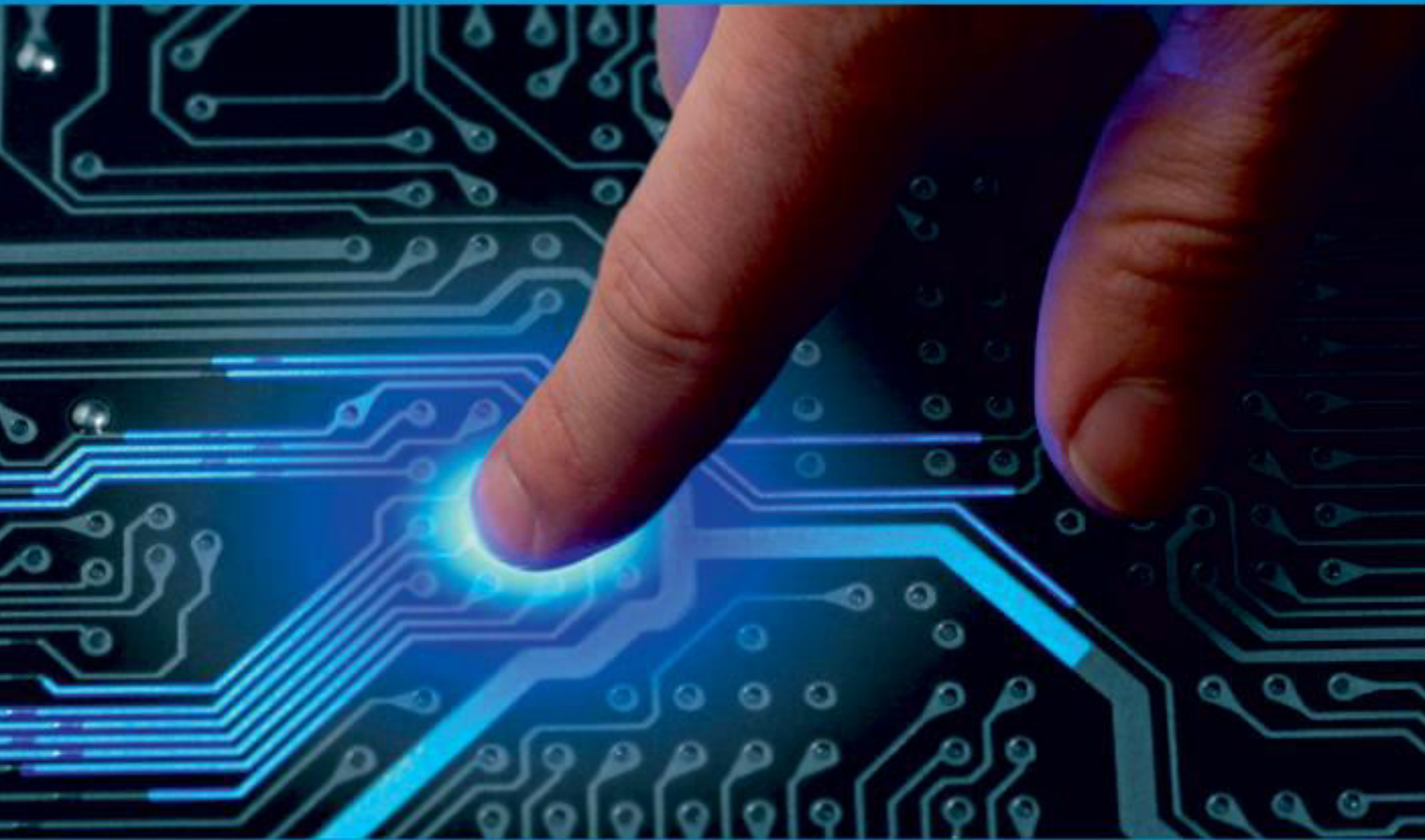
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 10, Issue 7, July 2022

Impact Factor: 8.165

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| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.165

|| Volume 10, Issue 7, July 2022 ||

| DOI: 10.15680/IJIRCCE.2022.1007081 |

Survey on Energy Consumption in Cloud Computing

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ABSTRACT: Cloud computing is the well-known technology for scaling of extensive data and complex computation. It has changed the model of storing and managing data for scalable, real time, internet based applications and resources satisfying end users' needs. More and more remote host machines are built for cloud services causing more power dissipation and energy consumption. Over the decades, power consumption has become an important cost factor for computing resources. We propose an analysis of the critical factors affecting the energy consumption in cloud computing and consideration to make performance very fast. This can be done by increasing throughput, minimizing response time and increasing resource utilization. The Power Consumption (PC) rate will increase simultaneously, with DC (Data Center)'s size expansion or increase in the number of DCs to fulfill the needs of data storage, processing and hosting demands. The Green Cloud computing solves the problem of global warming by providing eco -friendly environment. We studied that the heat emission increases with increase in energy consumption.

KEYWORDS*:* cloud computing, energy consumption, green cloud computing, virtual machine management.

I. INTRODUCTION

Cloud applications are deployed in remote data centers (DCs) where high capacity servers and storage systems are located. A fast growth of demand for cloud based services results into establishment of enormous data centers consuming high amount of electrical power. Energy efficient model is required for complete infrastructure to reduce functional costs while maintaining vital Quality of Service (QoS). Energy optimization can be achieved by combining resources as per the current utilization, efficient virtual network topologies and thermal status of computing hardware's and nodes [1].

Modern data centers, operating under the Cloud computing model, are hosting a various applications ranging from those that run for a few seconds (e.g. serving requests of web applications such as e-commerce and social networks portals) to those that run for longer periods of time (e.g. simulations or large dataset processing). Cloud Data Centers consume excessive amount of energy. It is accountable for global increase in energy consumption, and energy cost additionally. Now days the incipient software which are being used are devouring more and more power per year. Some of them require virtually steady access to the hard drive which drains power more rapidly than precedent software did [3].

The data centers are used to host the cloud applications are normally consuming enormous amount of electrical energy, which yields increment in operational cost and more emission of Co_2 for the environment [4]. Cloud service providers need to adopt measures to ensure that their profit margin is not dramatically reduced due to high energy costs. Lowering the energy usage of data centers is a challenging and complex issue because computing applications and data are growing so quickly that increasingly larger servers and disks are needed to process them fast enough within the required time period [5].

With the energy consumption issues and the shortage of resources become more and more serious, how to optimize the energy consumption of cloud computing by using the limited resources is particularly critical [8]. A number of practices can be applied to achieve energy efficiency, such as improvement of applications' algorithms, energy efficient hardware, Dynamic Voltage and Frequency Scaling (DVFS), terminal servers and thin clients and virtualization of computer resources [10].

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Green Cloud computing technique is used to reduce the energy consumed by physical resources in data center and save energy and also increases the performance of the system [7]. In cloud, the machines are running for providing web services and these machines also consumes some amount of energy for working. The cloud computing which focuses on reduction of energy consumption is known as *Green Cloud computing* [1]. In data center, the physical machines emit heat and harmful gases. The green cloud computing can also be used for e-waste management [2]. The reduction of energy consumption can be controlled on two bases: one is hardware and other is software. For controlling energy consumption on hardware basis, the hardware devices are used and likewise on software devices by using program and algorithms.

II. ENERGY CONSUMPTION ARCHITECTURE

The architecture of our energy-saving mechanism is based on Optimization, Reconfiguration and Monitoring. The entire state of Cloud environment is automatic monitored.

This state is recurrently analyzed by the Optimization module in order to find a surrogate software application and service allocated configurations that enables energy minimization. Figure 1 represents, Once an appropriate energy-saving configuration is detected base on the required measurers, the loop is closed by issuing a set of action on Cloud environment to reconfigure the allocation of this energy-saving setup.

Monitoring and Reconfiguration modules communicate with the Cloud environment monitoring framework to perform their tasks. Figure 1 represents, The Optimization module ranks the target configurations, this is established by applying energy-saving policies without violating existing Service Level Agreements (SLA), with respect to their energy consumption that are predicted by the Energy Calculator module. The accuracy predictions of this module is essential to take the most appropriate energy minimization decisions, it has the ability to forecast the energy consumption of Cloud environment after a possible reconfiguration option.

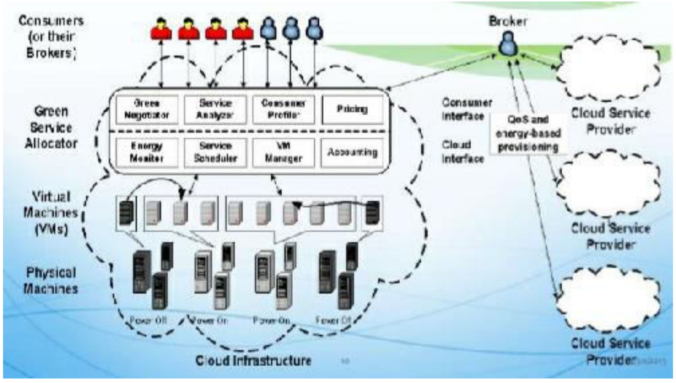

Figure 1: Energy Consumption Architecture

III. ENERGY USAGE IN DATA CENTER

With the growth of cloud computing, large scale data centers have become common in the computing industry, and there has been a significant increase in energy consumption at these data centers, which thus becomes a key issue to address. As most of the time a data center remains underutilized, a significant amount of energy can be conserved by migrating virtual machines (VM) running on underutilized machines to other machines and hibernating such underutilized machines. As the data center industry grows increasingly obsessed with energy efficiency, cloud computing presents a compelling opportunity to reduce data center power bills, according to a leading expert on IT power issues. Energy use is a central issue for data centers. Power draw for data centers ranges from a few Kilo Watt for a rack of servers in a closet to several tens of Mega Watt for large facilities. Some facilities have power densities more than 100 times that of a typical office building [5].

A. Energy Efficiency:

The most commonly used metric to determine the energy efficiency of a data center is power usage effectiveness (PUE). This simple ratio is the total power entering the data center divided by the power used by the IT equipment.

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Power used by support equipment, often referred to as overhead load, mainly consists of cooling systems, power delivery, and other facility infrastructure like lighting. Four areas where cloud computing have power efficiency advantages:

1. Diversity: Spreading computing loads across many users and time zones can improve hardware utilization.
2. Economies of Scale: Computation is cheaper in a large shop than small shop, as fixed costs can be spread over more servers and users.
3. Flexibility: The management of virtual servers in cloud apps is easier and cheaper than managing physical servers. It also has reliability advantage that can create savings in the data center. If you can void outages using software to route around problems, you don't need to buy two power supplies for each server.
4. Enabling Structural Change: The shift to a cloud model enables broader efficiencies in a business that can save money over time [5].

IV. ENERGY CONSUMPTION ANALYSIS

To calculate the amount of energy consumed by data centers, two metrics were established by Green Grid, an international consortium [10]. The metrics are Power Usage Effectiveness (PUE) and Data Centre Infrastructure Efficiency (DCiE) as defined below [1]:

PUE = Total Facility Power/IT Equipment Power
DCiE = 1/PUE = (IT Equipment Power/Total Facility Power) x 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, and power supply unit and storage capacity. The overall energy consumption of a cloud environment can be classified as follows [9]:

ECloud = ENode + ESwitch + EStorage + EOhters
Consumption of energy in a cloud environment having n number of nodes and m number of switching elements can be expressed as:

ECloud = n (ECPU + EMemory + EDisk + EMainboard + ENIC) + m(EChassis + ELinecards + EPorts) + (ENASServer + EStorageController + EDiskArray) + EOthers [1].

V. STATISTICS OF ENERGY POWER EFFICIENCY IN CLOUD COMPUTING

The statistics of Energy efficiency in cloud computing is surveyed and following data is found:

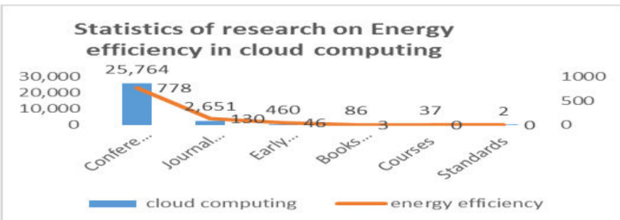

Figure 2: Statistics of Energy Power Consumption in Cloud Computing

From the above survey it is found that energy efficient cloud computing is only 10 % and have 3.4% of books and eBooks on energy efficient cloud computing. There are no standards and courses energy efficiency cloud computing. The plot of above statistic is shown in fig.2. Where the x-axis represents data type and y-axis gives the count.

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VI. OVERVIEW OF ENERGY REDUCTION TECHNIQUE

In general, green cloud computing can be implemented via three approaches: software optimization or network optimization in order to reduce the power consumption.

A. *Software techniques*

There are two software approaches for energy consumption reduction: reducing the energy consumed by servers (by reducing the number of active servers), and reducing the energy consumed by memory (by reducing the number of running memory nodes).

I. Reducing Server Consumed Energy

The energy consumption of servers can be decreased by reducing the number of active servers. This is usually implemented by scheduling optimization, which is a common approach for green clouds and is considered [11] more efficient than hardware optimization, in terms of cost, consumed resources and scalability. It depends on finding a suitable mapping between requests for Virtual Machines and physical servers to minimize the amount of consumed power.

II. Reducing Memory Consumed Energy

BNF schedules the VMs based on the popularity of individual memory nodes, the number of VMs that use the memory node in the entire computer system. Memory power simulator, called MPSim, is developed to evaluate the scheduling algorithms. The consumed energy, the average elapsed time to schedule a VM and the average waiting time of VMs in running queue are measured.

B. *Hardware techniques*

Other technique reduce the consumed energy by utilizing flexible hardware that varies the server computing capability via controlling the frequencies and voltages in the server, which affects the energy consumption [31][33]. However, as with all other hardware techniques, this approach to green cloud is costly and suffers from poor scalability because of the special hardware requirements.

A power-aware scheduling algorithm is presented in [23]. It implements Dynamic Voltage Frequency Scaling (DVFS) technique, which is applied with a number of special processors that can to operate at different voltage and frequency levels. It selects the appropriate supply voltages and frequencies of processing elements to minimize energy consumption without violating the SLA, based on the VMs workload. Each VM is allocated to the First Fit server, and each server applies the DVFS to save the energy while complying with the SLA requirements. The result shows a reduction in energy consumption without violating the SLA, and is compared with a non-power aware algorithm. It is implemented by using CloudSim toolkit and it is provided as an example in the simulator.

C. *Network techniques*

The communications between VMs consumes energy in the datacenter [6]. Reducing the network traffic between servers reduces energy consumption. The studies consider the network traffic of the VMs placements to reduce the energy consumption. Datacenter Energy-efficient Network-aware Scheduling (DENS) is proposed in [24]. It aims to reduce the energy consumption in a datacenter by optimizing the tradeoff between task consolidation and traffic pattern distribution. The proposed DENS select the best-fit server to execute a job based on weighted computational function that considers the load and the communicational potential at server, rack.
The proposed function converge VMs towards the maximum loaded server in the least-utilized rack with low network traffic [21]. In summary, network optimization techniques provide a reduction in the energy consumption with the ability to meet the SLA. They used the CloudSim 3.0 toolkit to simulate a datacenter with heterogeneous physical hosts and computed the energy consumption.

VII. VM MANAGEMENT TECHNIQUE IN REDUCING ENERGY CONSUMPTION

Another key aspect of a Green Cloud framework is virtual machine image management. By using virtualization the use of live migration features within Cloud systems is a recent concept. Live migration is presently used for proactive

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fault tolerance by seamlessly moving VMs away from failing hardware to stable hardware without the user noticing a change in a virtualized environment. Live migration can be applied to Green computing in order to migrate away machines.

VMs can be shifted from low load to medium load servers when needed. Low load servers are subsequently shutdown when all VMs have migrated away, Thus conserving the energy required to run the low load idle servers.

This process of dynamically allocating and de- allocating physical machines is complementary to our scheduling system. When load increases, we use Wake on LAN (WOL) to start them back up. This control can be easily monitored and implemented as a daemon running on the Cloud head node or scheduler. This effectively displays the goal of the Green Cloud Framework: while any single power saving technique can be beneficial, the calculated combination of multiple techniques from a systems-level perspective can yield significant power savings when compared to their individual implementations.

VIII. **CONCLUSION**

In general, the growth of cloud computing has led to uneconomical energy consumption in data processing, storage and communication. The massive energy consumption is unfriendly to the environment because of the huge carbon footprints of the datacenters. Therefore, green cloud computing is required to support the environment. Green computing produces environmental-friendly and cost-efficient cloud computing by using computing resources more efficiently.

IX. FUTURE SCOPE AND RESEARCH DIRECTION

Future scopes for further research are there in designing more power efficient hardware, scheduling algorithm, cluster configuration as well as energy-aware network protocols. The future scope is to optimize energy consumption and provide response time guarantee by considering the performance parameter and also by increasing the data volume so as to reduce the expenditure of cloud providers.

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