Power Reduction Techniques in Cloud Computing

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Abstract— **Cloud Computing has become one of the important latest emerging technology in IT world. Cloud Computing technology will offers servers, storage, software and platform for developing the application to the users as a service on pay per usage basis dynamically as needed. Presently cloud computing facing security, resource management, power consumption and cost concern problems. In data centers the power consumed by the computing components is very high and cooling system used to cool the servers in data centers will also cost very high. The large amount of heat and CO2 gas is released due to high power consumption and this leads to increase in carbon emission rate that is polluting the natural environment. Therefore minimizing the energy/power consumption will not only reduce the huge cost, but also protects our natural environment and provides green computing. This paper mainly presents various existing power/energy consumption techniques in cloud computing.**

Index Terms— **Cloud Computing, Power Consumption, Green Computing.**

I. INTRODUCTION

Cloud Computing is a latest technology in which all computing resources like software, hardware and platforms are provided as a services to the customers for developing the applications through internet. Customers do not have to invest money to purchase, manage, maintain and scale the physical infrastructure. The customers can take the required resources on demand from the cloud providers and pay for it as they use. There are different kinds of cloud:

• **Private cloud:** In Private Cloud the infrastructure is operated solely for an organization. It is managed by the organization or a third party.

• **Community cloud:** In Community cloud the infrastructure is shared by several organizations and supports a specific community that has shared responsibilities.

• **Public cloud:** In Public cloud the infrastructure is provided to the general public or a large industry group and is owned by an organization selling cloud services.

• **Hybrid cloud:** In Hybrid cloud the infrastructure is a combination of two or more clouds (private, community, or public).

Cloud providers provide mainly three types of services to the customers.

Software-as-a-Service (SaaS): SaaS model allows the users to use the applications supplied by the service provider in a cloud infrastructure. These applications can be accessible from different client devices such as a thin-client interface for example Web browser. The services offered by SaaS are:

• Enterprise services like communications, digital signature, customer relationship management (CRM), workflow management, supply chain, desktop software, and financial management.

• Web 2.0 applications such as social blogs, social networking, and portal services.

Platform-as-a-Service (PaaS): In PaaS model, the service provider will provides development tools, operating system and virtualized server as a service. Using these services users can deploy, test, manage and develop new applications in a cloud environment or run existing applications. These applications are made available to users via the internet. Google App Engine is an example for PaaS service.

Infrastructure-as-a-Service (IaaS): In IaaS model, the service provider owns the equipments such as hardware, servers, storage and networking components and all these are provided as services to the clients. The client will pay money on per-use basis. Amazon elastic Compute (EC2) and Simple Storage Service (S3) are examples for IaaS.

II. POWER/ENERGY CONSUMPTION

In data centers servers are running all the time since they requires huge power consumption, due to this large amount of heat is released. To remove this heat cooling system is used for cooling the servers. The cost spent for power and cooling system sometimes exceeds the cost spent for servers, network and storage. The power consumption by data centers all over the world is estimated at 26 GW which is equivalent to the 1.4% of world wide electrical energy consumption and it is increasing at the rate of 12% every year [1]. Due to the power dissipation huge amount of heat is released from servers and this heat may leads to the system failures and also large amount of CO2 gases are released which is the major pollution factor in the environment. In order to overcome these problems various authors provides various techniques to reduce the power consumption, release of CO2 gases.

Therefore minimizing the Energy/Power Consumption will not only reduce the huge cost but also improves the system reliability and also helps in protecting our natural environment.

III. TECHNIQUES TO REDUCE POWER CONSUMPTION

Awada Uchechukwu et al. [1] proposed Energy Consumption Architecture and presented a formulations and solutions for green cloud environments to minimize the energy consumption by considering static and dynamic portions of the cloud components. Here authors presented the formulas for calculating the total energy consumption in cloud environments, where the total energy consumption of an active server is equal to the sum of energy consumption of server in idle mode, cooling system, storage resources, computing resources, communication resources and energy generated by scheduling overhead. These formulas will help in saving the energy. The architecture of energy-saving mechanism as shown in figure.1

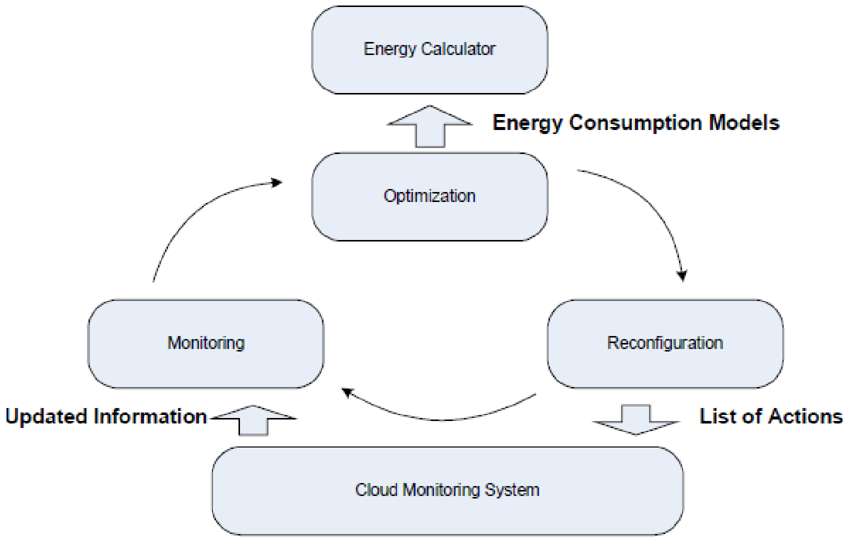

Figure.1 Energy Consumption Architecture

Here the entire state of cloud environment is automatically monitored and this state is continuously analyzed by the optimization module in order to find an alternate software application and service allocated configurations that enable energy minimization. Once the energy saving configuration is found then the loop is closed by giving a set of actions on cloud environment.

Sherry Arora et al. [2] proposed an **Energy Aware Resource Scheduler (EARS)** that schedules the tasks by using different algorithms for the data centre's node by knowing the temperature of node and task. Thus saves the power and heat. The temperature of the node is predicted by using prediction method, where the Prediction method = initial temperature of the task + (Execution Time of Task * per rise in temperature). EARS algorithm (EARSA) will schedule the tasks to the specific node that fulfil the task requirements and also based on calculated temperature of the node. This will help in saving power consumption in data centres and reduce the occurrence of system crash and task failure.

Sherry Arora et al. [3] made an analysis on **Energy Aware resource Scheduler with and without Scheduler**. EARS Algorithm will work on the parameters like Power Consumed, number of system crashed and CPU burst time. When the task is executed with and without using scheduler as a result a graph is obtained in which tasks will be appearing with check boxes by selecting a task through checkbox and we have to click on execute with scheduler and then without scheduler this will give the result corresponding to all parameters like energy consumed, system crash and power saved, by comparing both the results it can be conclude that power consumption can be reduced by executing the tasks by using scheduler.

Poulami Dalapati et al. [4] proposed a Green scheduling algorithm which performs both load balancing and power consumption management. The proposed framework saves the consumption of energy by identifying and turning off the idle CPUs and rescheduling services from overloaded CPUs to under loaded CPUs. In the proposed framework, tracker component keeps track on the status of VMs and also checks for information of power consumption. If service is accepted, tracker first assigns service to QoS checker. The QOS checker module fixes up the service level agreement and the price of the requested service. Then services are submitted to service execution manager that interacts with power consumption policy maker. This policy maker in turn interacts with virtual machines turn on-off decider. Finally VM turn on-off decider turns the required number of VMs ON to carry out services and assigns services to VMs using service assigner. A recorder keeps resource using record. It sends the services from active VMs to active CPUs of IaaS using mapping of service from virtual machine to IaaS. Hence all the CPUs of IaaS are not turned on, only those which are required are turned ON and the rest are turned OFF. Like this the power consumption of energy is minimized along with minimization of operational cost and the emission of carbon dioxide gas to the environment. They also presented a technique for optimizing server power consumption in cloud computing environments by sending the unused servers in sleeping mode using Bee Colony Optimization for service rescheduling and Ant Colony Optimization for power consumption management that identifies the idle CPU's and turning them off.

Arthi T et al. [5] proposed an Energy awareness model for server provisioning. In this model, unwanted power consumption can be reduced with the help of pre-processed data. Mainly Pre-processed data maintains statistical data such as transport cost between client and server and also between service expectancy and service map. Trigger engine is a component that reads the pre-processed data so that migration is initiated or the server will be turned off based on server expectancy. Automatic live migration is also developed in this model. Live Migration provides special benefit for data centers in a various process such as power management, load balancing and transparent IT maintenance. In this proposed model, automatic live migration of VM is initiated by the component called Trigger engine to reduce the power consumption depending upon the pre-processed data.

Syed Moshssen Ghafari et al. [6] proposed a new power aware load balancing technique called **Artificial Bee Colony Algorithm Minimal Migration Time** (Bee-MMT).The proposed algorithm is mainly based on artificial bee colony algorithm (ABC) that detects underutilized hosts, then migrate all VMs which have been allocated to these hosts to the other hosts while keep them not overloaded and then switch hosts to sleep mode. Evaluated results shows that the proposed algorithm reduces the power consumption, CO2 and also decreases the operational cost compared to other existing techniques like Dynamic Voltage Frequency Scaling (DVFS), Inter Quartile Range-MMT. The author also discussed that there is a trade-off between energy consumption and providing high quality of service to the customers. The proposed algorithm declines the power consumption. However, it has more SLA violation than the other methods. But percentage of increasing in SLA violation in Bee-MMT is much less than percentage of reducing energy consumption compared to other methods.

ZhengKai Wu et al. [7] proposed a power budgeting design using a distribution tree. In this presented design, a distribution tree is developed based on workload or service types. The author discussed two types of power consumption: physical level and logical level. In physical level power consumption method power consumption for the same users is calculated and in logical level power consumption method power consumption for the same services is calculated. The authors proposed a method that uses logical level power consumption method and they introduced classified power capping as the control-reference policy in cloud computing on logical level for different services. The classified power capping sets the power budget of mixed network groups more close to actual power needs based on performance requirements and saves more power.

V.K. Mohan Raj et al. [8] proposed a heuristic approach for sleep state at server level using VMs to processing application requests. In this approach, the incoming requests are scheduled to a physical server which would consume the least power for the application. It uses the possible server states {BUSY, IDLE, SLEEP, OFF, SETUP}.BUSY state indicates that the server is processing requests running in one or more of its VMs. IDLE state indicates that the server has not processing any requests. SLEEP state indicates that the server is in reduced power state. OFF state indicates that the server is in switched off state. SETUP state indicates that the server is transitioning between two states for example, SLEEP to IDLE state or OFF to IDLE state. The algorithm transits physical server between BUSY-IDLE, IDLE-SLEEP, SLEEP-OFF, and OFF-IDLE, SLEEP-IDLE, IDLE-BUSY states by finding appropriate VM for the incoming request that consumes least power.

Bharti Wadhwa et al. [9] proposed a new technique that reduces the carbon dioxide emission rate and energy consumption in the distributed cloud data centers having different energy sources and carbon footprints rates. This technique uses the carbon footprints of all the data centers in distributed cloud architecture, virtual machine allocation and migration technique inside each data center for reducing the emission of carbon and energy consumption in the federate cloud systems.

Rasoul Beik [10] proposed an energy aware layer in software architecture that evaluates micro-metrics and macro-metrics of energy consumption in data centers and then schedules services to the hosts that consumes less energy. Micro metrics are the metrics that are used to determine the amount of energy consumed when a service is run on a CPU and Macro metrics are the metrics which are used to determine overall energy consumption in data center. Based on defined micro metrics and macro metrics, the energy aware layer is responsible for locating the best hosts where a service can be run with respect to the consuming energy efficiently.

Anubha jain et al. [11] presented a new ideas for improving power performance of data centers. Here authors discussed that the data centers and processor chips generate more heat, this requires more cooling. Again the cooling system generates heats. Thus need techniques to balance the system by getting the same computing speed at decreased energy consumption. Here authors proposed different ideas about green cloud computing approach. First they specified the various metrics for analyzing power performance of data center that includes Thermal Design Power, Power Usage Effectiveness, Data center Infrastructure Efficiency, Performance per Watt, Compute power efficiency, Green Energy co-efficient and so on as shown in below table.

TABLE I. ENERGY-EFFICIENCY METRICS FOR DATA CENTERS

Metric	Description	Formulation
PUE	Power Usage Effectiveness	$PUE = \frac{\text{Total data center energy}}{\text{Total IT energy}}$
DCiE	Data Center Infrastructure Efficiency	$DCiE = \frac{\text{Total IT energy}}{\text{Total data center energy}}$
CUE	Carbon Usage Effectiveness	$CUE = \frac{\text{Total CO2 emissions from DC energy}}{\text{Total IT energy}}$
ITEU	IT Equipment Utilization	$ITEU = \frac{\text{Total measured energy of IT}}{\text{Total specification energy of IT}}$
DCP	Data Center Productivity	$DCP = \frac{\text{Useful energy}}{\text{Total facility power}}$
WUE	Water Usage Effectiveness	$WUE = \frac{\text{Annual water usage}}{\text{IT equipment energy}}$

Then author proposed different ways to reduce the power consumption in the data center such as by reducing CPU power dissipation, by using Advance clock gating, by using Split plan power, by using energy efficient processors, using Renewable energy sources, using Energy efficient storage and by reducing cooling requirements that minimize the power consumption of cloud.

B.Heller et al. [12] proposes an energy aware network optimizer **ElasticTree**. The ElasticTree selects the set of network nodes which must stay active to meet network performance and turns off the power for many unused links and switches. ElasticTree is configured that satisfy performance, fault tolerance, while minimizing their network power bill. The set of active network nodes that satisfies the required performance are selected using greedy bin-packer method, topology aware heuristic and prediction methods. The simulation result shows that ElasticTree can save around 50% of energy in data center.

Dragos et al. [13] proposed an Energy-aware placement of VMs framework that reduces the energy consumption of data center. The algorithm finds resources that are not used at their maximum capacity and resources that are not used at all. Then it migrates such resources between different data centers and turn off hosts that are not used. The proposed framework contains four main modules Analyzer, Allocator, Controller and Data center, which communicates between them and also with the data center .The main objective of this framework, is to migrate some resources between data centers in order to turn off some hosts that are not used so that cost can be reduced significantly .The Analyzer component is resource monitor that takes the system and network parameters from the data center and measures. If the measured parameters are higher than a predefined threshold, it transmits the parameters to the VM allocator. Depending upon the received parameter, allocator component reallocate the VMs in the data center. The Controller component is a data center interface module that is able to migrate VMs. This component receives the input from the allocator with new requests about VM migrations and performs migration by communicating directly with the data center and the hypervisors of the VMs.

J.F.Botera et al. [14] presents the Mixed Integer Program (MIP) formulation of the virtual network embedding problem (VNE) for energy awareness. The proposed approach realizes the mapping of the virtual network in a small set of substrate node and links (called active resources). The remaining unused links and nodes are deactivated by switching them off to minimize the overall network consumption of the substrate network. In the presented method, each time when a link is switched off the energy will save in the pair of interfaces on its ends and each node can be switched off only when all its interfaces are also switched off.

Weisheng Si et al. [15] proposed an energy aware distributed scheme called **eAware.** In eAware, ports and the switches have two states: idle and active. The proposed method examines the queue lengths, utilization of switch ports and idle network elements. If the queue length of a port exceeds certain threshold, then it activates other ports to decrease the queue. If the port has zero queue length or its utilization is low, it will be made idle. If in case all the ports of a switch are idle, then the switch will be made idle. Simulation results show that eAware can save 30%-50% of energy in data center compared to the existing energy oblivious approach.

Susan et al. [16] proposes smart strategies for replicating files and to minimize the amount of energy consumed in a data grid. Data grids will provide the ability to solve large-scale applications which require the processing of large amounts of data which is recognized as energy inefficient. Computing elements can be present far away from the data storage elements. A general solution to improve availability and file access time in these environments is to replicate the data. This will results in the creation of copies of data files at many several sites. The energy efficiency of the data centers storing this data is one of the biggest issues in data intensive computing. Hence power is needed to transmit, store and cool the data so they proposed to minimize the amount of data transmitted and stored by utilizing smart replication strategies that are data aware. Here authors will presents a replica strategy called Sliding Window Replica Strategy (SWIN).It is designed to minimize the amount of data transmitted and storage needed.

This strategy is implemented on sage cluster which is both energy and cost efficient. Performance results on the sage cluster will shows that the SWIN strategy performs better than strategies like LRU, MRU and LFU. By using SWIN more Power can be saved.

Xu et al. [17] proposed a Throughput Guaranteed Power Aware Routing Algorithm. The main aim of this algorithm is to use very little network power to provide the routing service. The proposed routing algorithm will computes the routes for the traffic flows called as basic routing and the corresponding network throughput called basic throughput. Then this algorithm slowly starts removing the switches involved in the basic routing, according to workloads of switches until the network throughput decreases to the throughput threshold the system can tolerate. Next starts removing as many links connected to the active switches as possible from the updated topology based on a link elimination strategy while ensuring the network throughput to meet the throughput threshold. Finally, we obtain the power aware routing paths for the traffic flows .Then finally power off the switches and links not involved in the final topology or put them into the sleep mode for power conservation. Thus energy is saved in the data center.

Yangfei Li et al. [18] proposed a technique called **EECLOUD** that deals with the energy efficient resource management in Map Reduce-based cloud. In this proposed technique, energy efficiency is achieved based on two strategies VM allocation and dynamic VM placement. VM allocation strategy allocates appropriate virtual resources for jobs through a utility function that compromises both execution time and energy. VM Placement strategy maps VMs to minimum amount of hosts.VM host mapping algorithm called VM Bin-packing is using by the VM placement strategy. A mapping algorithm will exploits live migration to make more space utilization for dynamically arriving workloads .The performance results shows that EECLOUD reduces the power saving by 40% when compared to the existing first fit algorithm.

IV. CONCLUSION

Cloud Computing provides everything to the user as a service that includes application as a service, platform as a service and infrastructure as a service. One of the major issues in cloud computing is power/energy consumption. Minimizing the Power/energy consumption in data centers will not only reduce the huge cost, but also improves the system reliability and also helps in protecting our natural environment. In this paper, we presented a survey of various existing energy efficient techniques that will reduce the power consumption in data centers.

V. ACKNOWLEDGMENTS

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