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Green Computing Metrics, Methods and Models

Prof. Dr. Girish Kumar Patnaik , Miss. Bhagyashree, P. Lokhande , Mr. Akshay G. Mahajan
Dept. of Computer Engg.Dept. of Computer Engg. Dept. of Information Technology
SSBT.s COE Jalgaon SSBT.s COE Jalgaon Sharadchandra Pawar COE Otur(Pune)

***Abstract*- In the cloud computing high performance of computing usage of data center and cluster is day by day increased. Energy consumption and energy dissipation in environment by data center also increased. The huge amount of CO2 dissipation in environment has generates the necessity of green computing. Green data centers referred energy aware, CO2 emission and energy efficient minimize design, devices and protocol also algorithms of data centers. Servers and network devices are consumed considerable amount of energy. Cloud computing is provides solution for saving energy by the green computing**.

Keywords:- Cloud computing, data center, green computing, energy consumption

I. INTRODUCTION

Green computing is study of designing and manufacturing of computers and servers also associated peripherals like as printers, monitors and networking devices efficiently with minimal in the environment.

Current situation the world facing problem of global warming which is caused by carbon emission is environment. About 98% of CO2 emissions (or 87% of all CO2-equivalent emissions from all greenhouse gases) can be directly attributed to energy consumption, according to a report of the Energy Information Administration. Many organizations today are speaking openly about a desire to operate in a "green" manner, publish the principles for environmental practices and sustainability on their corporate Web. In addition, various companies are now paying (or will pay in the near future) some kind of carbon tax for the resources they consume and they produce environmental impact of the products and services so a reduction in energy consumed can have a real financial payback. In this paper, we focused on reduction in energy consumption over the full equipment life cycle as the prime motivator for "green" application designing, with energy reduction as the best measure of "green-ness." Our sole motivation is reducing consumption of energy, without regard to economic impact. However, we observe that improving energy efficiency will also reduce economic costs, and energy costs are a significant contributor to the life-cycle cost of a data center.

a. Existing System

Reduction in Power consumption of cloud computing has become a challenging and innovative research topic in current scenario. For minimizing the operating cost of cloud environment several models have been designed.has proposed an optimized cost model for calculating total utilization cost of cloud. Many ideas have been proposed in literature to reduce power consumption. One approach for developing energy efficient servers is innovative interconnects technology. One such interconnect technology is Three dimensional stacking technology. It uses CMP (chip multiprocessor architecture) that greatly reduces power consumption. Pico Server is one such architecture that utilizes 3D technology to bond one die containing several simple slow processor cores with multiple DRAM dies that form the primary memory. In adopted DPM scheme. They proposed a solution to and the number of servers that should be active to meet the current requirements. That is called dynamically right-sizing. The problem is modeled as an optimization problem. An online solution is explored and an online solution called lazy capacity provisioning is proposed exploited from the online solution. The authors proved that the lazy capacity provisioning is 3-competitive that means it gives a suboptimal solution not larger than 3 times the optimal solution. The proposed algorithm is evaluated on two real traces, Hotmail and MSR. In addition it is shown that lazy capacity provisioning gives nearly optimal results.

Studied optimal power allocation in server farms by adjusting the CPU frequency. The authors carried out research on the effects of CPU frequency scaling on power consumption of servers. They studied on CPU intensive workloads and in their experiments. They applied DFS (dynamic frequency scaling), DVFS and composition of DFS and DVFS. The objective is to and optimal frequencies of servers thereby minimizing the response time. The authors gathered a linear power- frequency relation for DFS and DVFS however the experiments show that there is a cubic relationship for DFS+DVFS. The problem is modeled as a queuing problem which enables to predict mean response time as a function of power frequency relation. Another work focused on energy efficiency via server sleeping schedule is proposed an optimal power management scheme for an individual server farm. This optimal power management can dynamically reduce the power consumption of the servers in a farm by switching them to sleep mode. The study firstly formulated for single server farm as a constrained Markov decision process. Then multiple server farm case is considered. The performance metrics used in the study are, waiting time and job blocking probability while minimizing energy consumption. In this study, job broker is optimized to assign users to the server farms while minimizing the energy consumption and network cost.

III. METRICS USED FOR MEASURING POWER CONSUMPTION IN DATA CENTERS.

a) (TDE) Thermal Design Power

It is the measurement of maximum amount of power required by cooling of computer system to dissipate. It is the maximum amount of power which a computer chip can take when running a real application.

b) (PUE) Power Usage Effectiveness

It is used for comparison of energy used by computing application and infrastructure Equipment and the energy wasted in overhead. The PUE can be described as the ratio of overall electricity consumed by the facility of a data center to the overall electricity consumed by IT equipment's (network peripherals, servers, storage, routers, etc.). Value of PUE depends on the location of datacenters and construction done for that Datacenter. Thus it is different for all datacenters.

$$PUE = \frac{\text{Total Facility Energy}}{\text{IT equipment energy}}$$

c) (DCiE) Data center Infrastructure Efficiency

It is the reciprocal of PUE. PUE and DCiE are most commonly used metrics that were designed for the comparison of efficiency of datacenters.IT Equipment Power can be described as the power that data center has taken for the management of IT equipment's, processing of IT equipment's and storing the data in disk drives or routing the data within the datacenter. Total Facility Power is IT equipment power plus power needed by uninterrupted power supply (UPS), generators (needed to provide power in case of power failure),Batteries, cooling system components such as chillers, CRACs, DX air handler pumps, units, and cooling towers.

$$DCiE = \frac{1}{\text{PUE}}$$

$$DCiE = \frac{\text{IT equipment energy}}{\text{Total Facility Energy}}$$

d) (CPE) Compute Power Efficiency

It is a measure of the computing efficiency of a datacenter. As each watt consumed by server or cluster did not draw fruitful work all the time, some facility consumed power even in idle state and some consumed power for computing. Although 100% of facility capacity will never be used, but still we wantmaximum output from the electrical power which datacenter has taken. CPE is defined as-

$$CPE = \frac{\text{IT equipment utilization}}{\text{PUE}}$$

e) (GEC) Green Energy Coefficient

It is a measure of green energy (energy that comes from renewable sources) that is used by the facility of a datacenter. For evaluating the environment friendly nature of a data center this metric is used. It is selected as a PUE metric by green grid organization in November 2012. Energy consumed is measured in kWh. It is defined as-

$$GEC = \frac{\text{Green Energy Consumed}}{\text{Total Energy Consumed}}$$

f) (ERF) Energy Reuse Factor

It is a measure of reusable energy (energy that is reused outside of datacenter) that is used by datacenter. For making cloud, environment friendly data center should use renewable energy such as electricity generated by wind power, hydro power etc. ERF is selected as a PUE metric by green grid organization in November 2012. It is defined as-

$$ERF = \frac{\text{Reused energy used}}{\text{Total Energy Consumed}}$$

g) (CUE) Carbon Usage Effectiveness

It is a measure of carbon dioxide emission in environment by the data center. It is selected as a PUE metric by green grid organization in November 2012. Where ECO2: Total carbon dioxide emission from total energy absorbed by the facility of a data EIT: Total energy consumed by IT equipment's. ECO2 includes all greenhouse gases (GHGs) such as CO2 and methane (CH4) that are emitted in atmosphere. This value is taken for whole year analysis. It is defined as-

$$CUE = \frac{\text{E}_{CO2}}{\text{E}_{IT}}$$

h) (WUE) Water Usage Effectiveness

It is a measure of required water by a data center annually. Water is needed -
a) For cooling the facility of a data center.
b) For humiliation.
c) For apparatus associated power generating
d) For production of energy.
It is defined as-

$$WUE = \frac{\text{Water Used Annually}}{E_{IT}}$$

i) (DCP) Data Centre Productivity

It is a measure of amount of fruitful work yielded by datacenter. It is defined as-

$$DCP = \frac{\text{Useful Work Done}}{T_{resource}}$$

Where Tresource: total resource taken to produce this useful work

j) (DCeP) Data Centre Energy Productivity

It is a measure of amount of fruitful work yielded by datacenter with respect to energy consumed to yield this work. It is defined as-

$$DCP = \frac{\text{Useful Work Done}}{T_{energy}}$$

Where TEnergy : energy taken to produce this useful work

k) (SWaP) Space, Wattage and performance

It is a Sun Microsystems metric for datacenters. It is developed for computing the energy and space requirement of a datacenter.

$$SWaP = \frac{\text{Performance}}{\text{Space * Power}}$$

l) (ERE) Energy Reuse Effectiveness

$$ERE = \frac{\text{Total energy - reused energy}}{\text{IT equipment energy}}$$

m) (GPUE) Green Power Usage Effectiveness
GPUE was proposed by Green cloud to measure how much energy a computer data center uses, its carbon footprint per usable Kwh and how efficiently it uses its power.
GPUE = G _ PUE
Where, G is weighted sum of energy sources and their lifecycle

IV. COMPARISON RESULT

Metrics defined are insufficient in each proposed model and method.If we gather togetherthis all matric with Green Power Usage Effectiveness then we get a more powerful energy Efficiency model to reduce power consumption in data centers and data storage. TechniquesUsed for powerconsumption of cloud is much better than other. It includes more metricsFor getting more energy efficiency. Minimize power consumption of cloud is effective withproposed techniques. Green Power Usage Effectiveness (GPUE) metrics is useful to calculateenergy usage by computer data center GPUE metric not used by cloud consumption modelto calculate Green power Usage Effectiveness factor to make it more efficient.From comparing all metrics, we seen that if we combined this all metric together then we get more energy efficient model with powerful metric.

Author	Anubha Jain, Nitin Jain	Bhanu Priya,Ramesh C.Joshi	Derya Cav-dar,Faith Alagoz
Metrics			
PUE	✓	✓	✓
CUE	✓	✓	✓
WUE	✓		✓
ERF	✓		✓
ERE			✓
DCiE	✓	✓	✓
DCP	✓		✓
ERP			✓
GPUE		✓	
ESV		✓	
TDP	✓		
CPE	✓		
GCE	✓		
DCeP	✓		
SWaP	✓		

V. CONCLUSION

Green computing represents a responsible way to address the issue of global warming.By adopting green computing practices, business leaders can contribute positively to environmental stewardship-and protect the environment while also reducing energy and papercosts.Characterizing the energy use of enterprise computing systems is the first step towardidentifying opportunities forimprovement.Power consumption of clouds provides scalability, agility and reliability methods for energyefficiency and makes environment eco-friendly. Metrics define for making energy efficientsystem focuses on reduction of CO_2 emissionin environment and Green House Gases effectalso reduced in a large amount.Energy costs and electrical requirements of IT industry aroundthe world show a continuously growing trend.As we are moving towards cloud and using itsapplication in every field such as disaster management, service provisioning, online datastorage, data retrieval from any place at any time etc we must ensure it to be environmentfriendly otherwise the day will not be far when pros of cloud becomes cons for environment.

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