Green Cloud Computing: An Overview

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Abstract—Cloud computing is a highly scalable and techno-economic architecture for running HPC (High Performance Computing), enterprise and Web applications. As the use of huge data centres (DC) and huge cluster leaps up day by day, energy consumption by these DC is escalating quicker. This High energy consumption not only affects the high operational cost but also result into high carbon emissions. Optimal energy solutions are required to curb the impact of Cloud computing on the environment. Increased processor chips utilisation liberates more heat. This unnecessary heating requires more cooling and cooling again generates heats and thus we come to a stage where we want to balance the system by getting the same computing speed at decreased energy consumption. Cloud computing with green algorithm can enable more energy optimized use of computing power.

Index Terms—green computing, high performance computing (HPC)

I. Introduction

Cloud computing is a highly scalable and cost-effective architecture for running HPC, enterprise and Web applications. It uses huge data centers (DC) and huge cluster is increasing day by day so energy consumption by these DC. This High energy consumption not only affects the high operational cost but also result into high carbon emissions. Optimal energy solutions are required to curb the impact of Cloud computing on the environment. So this large amount of CO2 dissipa-tion in environment has generated the necessity of Green computing[5]. More processor chips generates more heat, more heat requires more cooling and cooling again generates heats and thus we come to a stage where we want to balance the system by getting the same computing speed at decreased energy consumption. Cloud computing with green algorithm can enable more energy-efficient use of computing power.

So it's required to reduce energy consumption and that we can achieve by reducing the rate of CO2. For that green computing is used nowadays which is the study and appli-cationof designing, manufacturing, utilising, and disposing of ICT — efficiently and effectively with minimal or no impact on the environment. There are several approaches to green computing, namely[1]

1) Product longevity
2) Algorithmic efficiency
3) Resource allocation
4) Virtualization
5) Power management

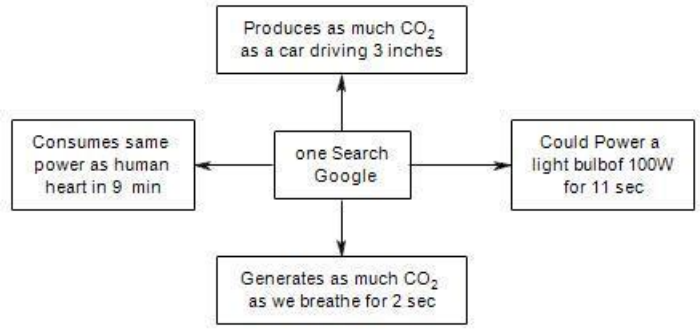

Figure 1. Energy utilised in one google search

II. Need of Green Computing

In Information technology, it is analysed that the personnel are not cautious of the consequences of foul operations. It is depicted that most of the computer energy is often wasteful by operational inadequacies. The reason to it is that we leave the computers on even in idle mode. The processer and heat fan consumes power. Even the screen savers consume power when the system is in idle mode. It is observed that most of the DCs do not have sufficient cooling utility capacities. This results in pollution of environment. This is because of defects in packaging, manufacturing techniques, disposal of computers and components i.e e-waste. Toxicity is an added disadvantage. The toxic chemicals used in the production of computer assembly and equipment which can enter the food chain and water. According to a source, "IT energy demand is increasing 12 folds faster than the overall demand for energy" and "DCs emit over 150 MT of CO_2 annually (and counting). (As per one survey report, a car produces roughly 1.8 kg of CO2 for every litre of petrol/diesel consumed.)"

It is a high time a technical personnel should understand the need of 'GREEN COMPUTING' while using ICT. Many technology companies have taken the initiative to promote the idea and standardise the consumption and take a step ahead towards green computing.[4]

Some of these green organizations are:

1) The Green Grid is a global association of IT industries and experts keen to upgrade energy productivity in data centers and business computing ecosystems across the world. Board members of The Green Grid includes APC, HP, Microsoft, Dell, IBM, AMD, EMC, Intel and Oracle.

prioritized over other consumers

2) The U.S. Environmental organization is a government organization that was built to preserve human health and to safeguard the organic environment. This organization also created a link program called Energy Star with the the U.S. Dept. of Energy and U.S. EPA

From the view of a end user in an organization there are various area that needs to be focus for building the GREEN IT.These are:

Energy/Power expenditure – while we utilize energy should be save

Reuse - after reuse disposal considerations should be taken so that we can understand Components are Useful or Unused

Hardware/Software- Importance on computer acquire

Energy utilization- Energy utilization and methodical ways to Computing.

Minimize misuse- Using computers to minimize the uti-lization of Organic resources.

III. GREEN CLOUD COMPUTING ARCHITECTURE

Before applying the concept of GREEN IT, It is important to understand the life cycle of computer This was explained with the help of following figure 2.The green computing cycle is as shown below[4]:

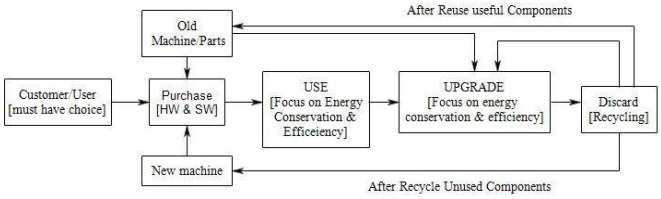

Figure 2. Green Computing cycle

From the view of a user in an organization, following are the area of focus for making the IT GREEN:

Energy Consumption – saving utmost while using

Recycling - Recycling most and limit e-waste

Energy use- Determining efficient ways to Computing. Hardware/Software- Purchasing a computer responsibly Reducing waste- Using computers to reduce the use of Natural resources.

Now architecture of green computing is shown in fig3. In green cloud architecture services provided to users. It has following main entities involved:

1) First end user will request for a cloud service. This request will be sent to Green Broker
2) Green Broker has Scheduler, Task Selector, application Profile, Green Resource Information, Cost Calculator, and Carbon Emission Calculator.
   Scheduler: It will schedule the task which is given by user.
   a) Task Selector : It will select the task
   b) Application profiler : Gather specific characteristics of consumers so that important consumers can be granted special privileges and
   c) Resource Information : Act as interface between cloud infrastructure and consumers
   d) Cost Calculator : Calculate cost of task
   e) Carbon Emission Calculator : applications are assigned to cloud providers with minimum carbon emission due to their data center location and carbon emission due to application execution
   So like this way, user's request will come to Green Broker. From Green Broker, request to any Green Cloud Offers
3) After that request to energy efficiency information. This will calculate Carbon Emission and store it to Carbon Emission Directory
4) Resource will be allocated to Private Cloud
5) Finally to give particular service to user request to cloud service for service allocation[3].

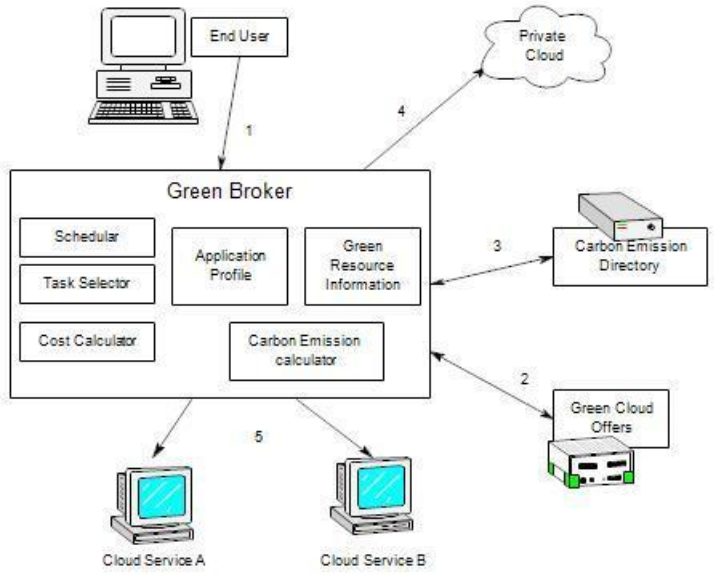

Figure 3. Green broker

IV. PARAMETERS USED FOR MEASURING POWER CONSUMPTION

Various parameters that are used to measure power consumption of a processor or data center are TDP (Thermal Design Power), PUE (Power usage Effectiveness), DCiE (Data Center infrastructure Efficiency), Performance per Watt, Compute Power Efficiency (CPE), GEC (Green Energy co-efficient), ERF (Energy Reuse Factor), CUE (Carbon usage Effectiveness), WUE (Water usage Effectiveness), Data Center Productivity (DCP), Data Center Energy Productivity[2]

Parameter	Description
Carbon usage Effectiveness(CUE)	It is a measure of carbon dioxide emission in environment by the data center. CUE=ECO2/EI Where , ECO2= Total carbon dioxide emission from total energy absorbed by the facility of a data center. EIT = Total energy consumed by IT equipments.
Water Usage Effectivness(EUE)	It is a measure of required water by a data center annually. Its defined as: WUE=Water used annually/EIT
Data Center Productivity(DCP)	It is a measure of amount of fruitful work yielded by datacenter. It is defined as- DCP=Useful Work-done/Tresource where, Tresource = total resource taken to produce this useful work
Thermal Design Power(TDP)	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.
Power Usage Effectiveness(PUE)	It is used for comparison of energy used by computing application and infrastructure equipment and the energy wasted in overhead. PUE = Total Facility Power/IT Equipment Power
Data Center Infrastructure Efficiency(DCiE)	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 is defined as: DCiE=1/PUE DCiE = IT Equipment Power/Total Facility Power
Performance per Watt	It is the processing rate that can be remitted by a processor for each watt of power absorbed by it. This must be high. It measures the rate of computation that can be delivered by a computer for every watt of power consumed by it.
Green Energy Coefficient(GEC)	It is a measure of green energy (energy that comes from renewable sources) that is used by the facility of a datacenter. Energy consumed is measured in kWh. It is defined as GEC=Green Energy Consumed/Total Energy Consumed
Compute Power Efficiency(CPE)	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 consumes power for computing. CPE is defined as- CPE=IT Equipment Utilization/PUE =(IT Equipment Utilization*IT Equipment Power)/Total Facility Power
Energy resuse factor(ERF)	It is a measure of reusable energy (energy that is reused outside of a datacenter) that is used by datacenter. ERF=Re-sued Energy Used/Total Energy Consumed

Table I
PARAMETERS USED FOR POWER PERFORMANCE

V. Proposed Different ways to reduce power consumption

We propose following techniques to minimize the power consumption of cloud[2]:

Proposition 1. By reducing CPU Power dissipation

Processor consumes electrical energy in form of charging (direct supply) for its operation, for the switching devices contained in it, for cooling of transistors and numerous chips. It dissipates this energy in surroundings

Proposition 2. By using advance Clock gating

Clock gater is a hardware switch that is responsible for activating and deactivating the clock. The clock of a logic block must be activated only when the logic block is doing some work and clock must be turned off when logic block is not performing any task.

Proposition 3. By using Split plane power

Splitting means division but in processor terminology splitting means division across horizontal axis. Here, motherboard supports split plane power supply and it will deliver separate power supply to processor and North Bridge. We can even go for nested splitting i.e. plane power can be divided into any number of region. Figure below is the diagrammatic representation of split plane power and unified plane power

Proposition 4. By using Energy-efficient Processors

With dynamic voltage scaling and dynamic frequency scaling the voltage of a processor, clock rate of a processor or both voltage and clock rate of a processor can be modified such that the power consumption of CPU is decreased.

Proposition 5. By using Renewable energy sources

All data center of clouds required diesel generator to provide backup power and with data center CO2 dissipation. We can use renewable energy sources such as hydro energy, wind energy, solar energy to generate electricity for fulfilling the power requirement and cooling requirement of these data center.

Proposition 6. By using Energy efficient storage

Now energy efficient storages are invented that can replace existing storages of cloud. As the life time of a data center is limited up to 9 years so while renovating existing data center developer can use energy efficient memory for e.g. solid state storage can be used. Solid state storage has no moving mechanical component as hard disk drive has. Due to this, solid state requires less cooling as compared to hard disk drive so now less energy will be needed for cooling.

Proposition 7. By Reducing Cooling Requirements

Previously cooling was done with mechanical refrigerator that takes service of compressor inside the data center or externally chilled water will be supplied to man air handler for the cooling of IT equipment. Now free cooling can be used instead of mechanical cooling. Free cooling is a system developed to optimize or minimize the requirement of cooling. It says if the air temperature of outside world is below or at the critical point, then the mechanical refrigerator can provide direct or indirect cooling by itself. Free cooling does not reduce the required fan energy for cooling it just eliminates the need of mechanical cooling energy.

VI. Conclusion

This paper presents new ideas for improving power performance of cloud application, data centers etc. First we explored various metrics for analyzing power performance of cloud computing and data center then we have proposed possible techniques to minimize the power requirement. Green Computing is the future technology that supports environment,

reuse consumed power and energy, and optimize the resources efficiently. Green computing focuses on reduction of CO2 emission in environment and thus makes IT industry environ-ment friendly. And Make your entire organization Green in every way possible. Understand the life cycle of IT products. Reduce as much paper as possible and recycle it when you can. Let's start working on it and embrace the future.

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