IMPLEMENTATION OF ENERGY EQUATION USED TO CALCULATE THE ENERGY USED BY THE DATA CENTRE

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ABSTRACT
Cloud computing can be defined as a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction[1].Cloud computing is becoming an increasingly popular enterprise model in which computing resources are made available on-demand to the user as needed. The unique value proposition of cloud computing creates new opportunities to align IT and business goals [2]. Cloud has been used in the various fields of IT sector due to its robustness and ease I in use feature. Anybody can access the data from anywhere in the world without any physical acceptance of data or travel thus saving money and time of the software engineers. Cloud also saves money in regarding cloud storage on demand or pay per use feature. By considering these concepts and features of cloud we had discussed in our previous paper about energy saving equation which had shown us the exact amount of energy which is required in the data centre [3]. In this paper we have iterated with the different values of the various factors which are used in the calculation of energy of the data centre. Thus these iterations will help us to know the actual amount of energy used in the data centre and help us to reduce the energy loses in data centre by taking appropriate measures.

KEYWORDS— *Cloud Computing, Cloud Services, energy calculating equation, losses, data centre.*

I. INTRODUCTION

A key differentiating element of a successful information technology (IT) is its ability to become a true, valuable, and economical contributor to cyber infrastructure. “Cloud” computing embraces cyber infrastructure, and builds upon decades of research in virtualization, distributed computing, “grid computing”, utility computing, and, more recently, networking, web and software services. It implies a service oriented architecture, reduced information technology overhead for the end-user, greater flexibility, reduced total cost of ownership, on demand services and many other things [4].
Energy efficiency is increasingly important for future information and communication technologies (ICT), because the increased usage of ICT, together with increasing energy costs and the need to reduce greenhouse gas emissions call for energy-efficient technologies that decrease the overall energy consumption of computation, storage and communications. Cloud computing has recently received considerable attention, as a promising approach for delivering ICT services by improving the utilization of data center resources. In principle, cloud computing can be an inherently energy-efficient technology for ICT provided that its potential for significant energy savings that have so far focused on hardware aspects, can be fully explored with respect to system operation and networking aspects. Thus this paper is the further work of our previous paper [3] where energy calculating equations were shown on the basis of some determined values. In this paper we have considered few iterated values and have done the analysis and through graphs we have shown that even the parameters of in our equation changes we still are able to calculated the better values of energy consumed in a data center when compared to other previously used equations as we are calculating with losses.

II. RELATED WORK

In our previous paper we have proposed an equation and showed that total energy in a data center can be calculated by the equation

$$E=\int_{t1}^{t2} PU(t) \text{ *losses} \quad (1)$$

where E is the energy utilized which is equal to the over all power utilized with respect to time multiplied by the heat losses. Assuming as the load of a data center increases with time the amount of power consumed by a data center also increases[3].

η = output/input

As input=output + losses,

Efficiency in percentage is given by

η=output /(output +losses)*100

The equation proposed here can be used to calculate the losses and energy consumed. This equation helps to know how much power we need to supply to the data center and what are the other losses that occur excluding the calculated one. As we know that the power required by a data center is not constant but depends upon the load and duration of usage of servers or systems. When we want to know how much energy is to be supplied to a data center we need to know the heat generated and the requirement of cooling systems. When we calculate the total energy requirement in a data center we need to calculate the losses that occur in a data center. We propose the following equation:

$$E_T=E_c+T_E+\int_t P_{CPU}+H_L \quad (2)$$

where E_T stands for total energy consumed by data center,

E_C is the energy required for cooling

T_E is the minimum energy consumed by both idle and active CPUs in data center

$\int_t P_{CPU}$ is the power consumed by the CPU with respect to time.

H_L is the heat loss caused by the components used in the data center[3].

2.1 Calculation of EC

E_C which is the energy consumed can be calculated as $E_C=N_S*H_G$ in joules

where N_S stands for minimum supply given to cooling system and H_G are the heat losses.

By considering the redundancy, the factor which is considered for the failure or servicing of the cooling equipment of any other equipment in a data center[3].

Therefore if we consider having redundant equipment (equipment which considers redundancy) we can re write the energy equation as

$$E_C=N_S+H_G+R \quad (3)$$

Where R stand for redundancy. If we have 100KW of power usage then we need 100KW of cooling plus redundancy to allow for cooling equipment failures and servicing. We may also need to add additional cooling capacity to allow electronic equipment lay out or computer room infrastructure design like load cooling delivery or overloaded areas.

2.2 Calculation of TE

T_E is the minimum energy consumed by both idle and active CPUs in data center which is given by $T_E= P_I+P_A$ where P_I is the power consumed by idle CPU and P_A is the power consumed by active CPU[3].

Authors [20] have proposed an equation

$$P=P_{fixed}+P_f .f^3 \quad (4)$$

Where P_{fixed} is the portion of the power consumed which does not scale with the operating frequency f, P_f is the frequency dependent CPU power consumption. And also we have from DVFS [19] is based on the fact that a switching power in a chip decreases proportionally to V^2.f, where f is the switching frequency. From this equation we can consider that voltage and frequency fluctuations are also the cause for energy loss in a data center .

2.3 Calculation of HL

H_L is the heat loss caused by the components used in the data center given by[3].

$$H_L= \int_t L_D.\ V_D+f_D \quad (5)$$

Where L_D is the load on the data center, V_D and f_D are variations in voltage and frequency respectively.
V_D is given by $V_D=V_{max}-V_{min,}$ which are maximum and minimum voltages respectively.
f_D is given by $f_D=f_{max}-f_{min}$, which are maximum and minimum frequencies respectively.

2.4 Calculation of∫t PCPU

We have to consider the losses which are function of time i.e. longer the CPU runs more is the power required. Therefore longer the CPU runs more will be the heat generated from CPU which can be calculated by [3]

$$\int_t P_{CPU}*H_L \qquad (6)$$

In this paper we are using that same equation which has been proposed in [3] and we are calculating the values of energy used in data center when parameters of the equation changes. This paper discusses methods which we can apply to save an appreciable amount of energy. We present energy saving equations based on the ones proposed in [5][6] and discuss calculations based on connection of CPUs and their cooling system requirements.

III. PROPOSED WORK

We have to consider some factors or methods which are required to reduce the losses in a data center we need to find the reasons that are contributing to the energy losses and the methods that can be adopted to reduce losses.
Substantial research [7][8][9] has been done on finding the methods to reduce the losses as follows:

- Conduct energy audit of the data center:
- Data center efficiency
  = IT efficiency*data center site infrastructure efficiency
  =IT output.
- Prioritize actions to reduce energy consumption.
- Use IT equipments with high efficiency power supplies: Power supply unit coverts incoming AC to DC and requires 25% of server's power budget (if power supply unit operates at 90% efficiency and voltage regulator operate at 85% efficiency the overall efficiency of the server will be greater than 75%).
- Use high efficiency UPS: IGBT switching devices have increased switching frequency, power conversion losses have decreased and the UPS could run at 85% top 90% efficiency.
- Adopt power distribution at 230V: Distributing power at 400/230V can be 3% more efficient in voltage transformation and 2 % more efficient in power supply in IT equipment. This slight increase in efficiency is still worthwhile a data center with 1000 servers could save $40,000.
- Adopt best practices for cooling: Use hot aisle/cold aisle enclosure configuration and use blanking panels inside the equipment to separate aisles.
- Turn off idle IT equipment.
- Remove bloat wares (ineffective software that use excessive CPU cycles).
- Virtualizing servers and storage which will improve server utilization from an average of 10% to 20% to 50% to 60%.

Consolidate servers, storage and data centers: At the server level blade servers can really help drive consolidation because they provide higher density computing for the power consumed (for a given amount of energy input we get more processing output from a blade server because each blade shares common power supply, fans, networking and storage with other blades in the same blade chasis .Use high speed drives only when they are necessary otherwise use larger disk drives as they are more energy efficient. There are other reasons for the energy losses in a data center like under floor cooling[10]. Energy management of data center to be done efficiently by the above methods in a well organized form[11][21].
Now in this paper we are assumed some values of our parameters used in the equation
By considering the equation proposed by the author[12][13].

$$E=\int_t P.U(t) \qquad (5)$$

Equation modified in us in paper [3].

$$E=\int_{t1}^{t2} PU(t) \text{ *losses} \qquad (1)$$

And our proposed equation

$$E_T=E_c+T_E+\int_t P_{CPU}+H_L \tag{2}$$

While calculating the energy utilization of a data center we have to consider both energy consumption in server systems and the energy required for cooling and in power delivery infrastructure [14]. We need to calculate the energy consumption by each server by using basic power consumption equation so that we can calculate the total energy consumed by the data center [15]. Some authors have calculated the energy consumption by a processor during idle time and during busy time [14][15] while some have proposed scheduling algorithms which involve varying the voltage and frequency based on requirements. Algorithms like DVFS can schedule voltage and frequencies of CPUs in low power active state and suspended inactive state.80% of overall emission for the complete product life cycle for the laptop are attributable to embodied energy while only 20% are due to energy consumption during usage while for a desktop PC and a monitor about 70% is contributed and for servers it is low as about 25% of lifecycle emission [16]. According to Green grid [17] the input to computer room i.e., Power Distribution Unit (PDUs is the most useful point for power measurement. This measured value gives the total power delivered to the server racks in data center. Else we were using some scheduling algorithms for tasks distribution and trying to save energy[18]. But unless and until we do not know what is the actual requirement of energy in a data center and which are the factors causing the energy loss it is difficult for us to use any energy saving methods. And of course we consider three phase supply as explain by the author[20]

The power calculation of a 3 phase system is given by equation as in [20]

$$KW=\sqrt{3}VI\cos Ø /1000 \tag{7}$$

Therefore we have proposed an equation for energy calculation and proved it to be better in calculating the energy in data center when compared to previous equations used for calculating the data center energy. We consider the as follows:

1. PU(t) =2,72,785.64 KWh
2. Take t1=0 and t2=8760hrs
3. Losses or HL=893.50KWh, Ec=1,64,978.1KWh, TE=2,304KWh

By taking these values we have plotted a graph of energy calculated in a data center for three different equations i.e (5),(1) and (2).

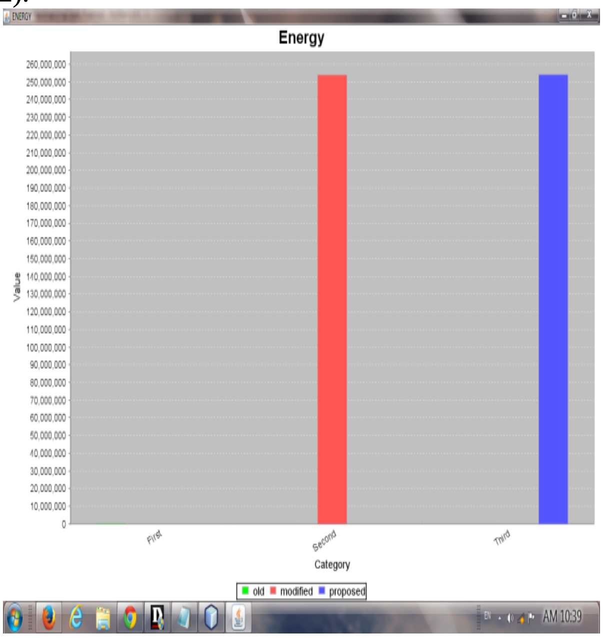

Fig.1: Graph of energy v/s various equations.

Fig. 2: Graph of CPU v/s Time duration of energy consumption.

This graph shows that when compared to equation (5) and (1) our prosed equation gives the better value of energy consumed in a data center as it is calculating the energy by considering the losses.
We further have varied the values of the parameters used in the equation and calculated the energy consumed in the data center so that we can find out even in the case of voltage fluctuations our equation will calculate energy accurately or not.

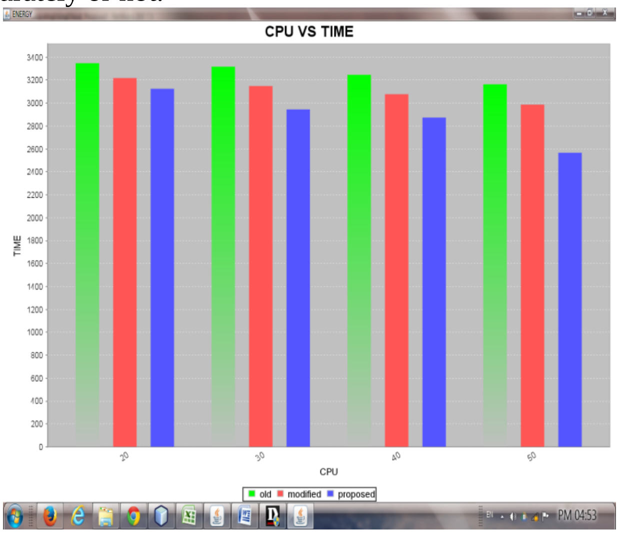

Fig.3: Graph of Time v/s energy loss.

Thus these graphs shows that even there fluctuations in a data center due to various parameters we can still calculated the required amount of energy used in the data center by using our proposed equation.

IV. Conclusion

The objective of this work has been to derive an equation to include the losses that occur in a data center and propose methods to reduce the losses and save the overall energy consumption in a data center. The work presented here will help in reducing the environmental hazards of ICT. Our paper show that by using our proposed equation we get to know the exact amount of energy data center required based on the capacity of the data center. Therefore we can save an appreciable amount of energy thus keep the environment clean and safe.

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