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An Enhancement of DVFS Algorithm for Cloud Computing

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ABSTRACT

Today's computing systems development focuses on the performance improvements powered by demands of applications. The performance growth of computing systems has limited because of energy consumption and carbon dioxide emissions. Therefore the focus of computing systems has been drifted from performance improvements to energy efficiency. This research paper proposes a technique that would reduce energy consumption of servers in the cloud datacenter by enhancing the performance of Dynamic Voltage Frequency Scaling (DVFS) algorithm. The Green cloud simulator which is an extension from network simulator is used. The simulator uses two languages C++ and Tool Command Language (tcl), where tcl supports the front end and it creates the traces of simulation which includes the parameters involved in it and the core code is written in C++.

Keywords:- Green cloud, data centers, energy optimization, DVFS, power models.

I. INTRODUCTION

The Cloud computing is a young emerging computing technology with an objective of offering reliable, adaptive and Quality of Service (QoS) based computing system environments for IT. One of the current concerns in cloud computing environment is uneconomical and inefficient usage of energy in data storage, processing and communication. This is harmful for the earth's atmosphere due to increasing carbon foot prints caused by carbon emission. So, green IT is required to rescue the earth's environment and the human kind. The green cloud computing approach is part of green IT which aspires to turn down the carbon footprint of cloud datacenters by decreasing their energy consumption.

Establishment of a cloud demands installation of a large number of computing utilities in a single data center. These computing resources can be thousands in number and may compute an huge amount of electric energy .On account of an report by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), it is established that by 2014 the cost of data center energy consumption and infrastructure would contribute 75% whereas cost of Information Technology would be just 25% of the overall cost of operating a datacenter[28].

The main factor which results in such a huge amount of energy consumption is not only the number or quantity of computer resources used or the inefficient use of part hardware, but it is rather the improper utilization of the resources. Researcher have found that most of the computer resources are not fully utilized .i.e. their utilization rarely reaches 100%. For Instance, the data from over five thousand servers was collected for their recourse utilization records for a period of six months, it was noted that although the servers were not completely idle but the utilization rarely hits the hundred percent [28].Most of the computing servers were marked to be operating around ten to fifty percent of their full capacity. This led to increase the expenditure levels even more because clearly lower level of utilization in servers, results in more energy being consumed that the severs would ever consume when it operates at a hundred percent utilization rate.

It should be noted that, the idle servers consume around seventy percent power of the highest level of power supplied to them. Therefore, targeting the utilization of computing servers to their full capacity and not keeping them completely idle can help in the achievement of energy efficient computing

Besides the direct energy consumption expenses, there is an additional expense of the cooling systems required in each datacenter to keep them cool. To each one watt of power consumed, it requires nearly 0.5 to 1 watt of power for the cooling systems [28].Clearly the more the number of resources used, the greater is the carbon dioxide emitted. This carbon dioxide emission leads to many environmental problems like global warming and greenhouse effect.

II. GREEN COMPUTING

Green computing is referred as the eco-friendly use of computers and its resources. Such practices involues the implementation of energy-efficient central processing units, servers, peripherals as well as reduced resource consumption and proper disposal of electronic waste. Green computing is a study and practice of designing , manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment." The goals of green computing are similar to green chemistry; reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote the recyclability or

biodegradability of defunct products and factory waste. Research continues into key areas such as making the use of computers as energy-efficient as possible, and designing algorithms and systems for efficiency-related computer technologies.
There are several approaches to green computing namely

- Algorithmic efficiency
- Resource allocation
- Virtualization
- Power management

Green Cloud simulator: Green Cloud is a sophisticated packet level simulator for energy-aware cloud computing data center with a focus on cloud communications. It offers a detailed fine grained modeling of the energy consumed by the data center IT equipment, such as computing server, network switches, and communication links. Green Cloud can be used to develop novel solutions in monitoring, resource allocation, workload scheduling as well as optimization of communication protocols and network infrastructures. It can simulate existing data centers, guide capacity extension decision as well as help to design future data center facilities.
Green Cloud, released under the General Public License Agreement, is an extension of the well-known NS2 network simulator. About 80 percent of Green Cloud code is implemented in C++, while the remaining 20 percent is in the form of Tool Command Language (TCL) scripts.

III. RELATED WORK

In [16], a three-phase energy-saving strategy is proposed. The proposed strategy includes algorithm for replica management, algorithm for cluster reconfiguration and algorithm for state transition. This enables flexible energy management. Simulations are performed and the results of the simulations show that the algorithm is fine for saving energy. But this method is theoretical one.

In [17], Adaptive Power-Aware Virtual Machine Provisioner (APA-VMP) is proposed. This policy schedules the workload such that the incremental sum of the power which is drawn by all the servers is minimized. This approach does not compromise with the system's performance.

[19] Describes the tools which are needed to be implemented in a simulator for the energy-aware experimentation. The paper emphasizes on DVFS simulation.

In [21], a new dynamic VM allocation policy is introduce. The policy takes VM`s according to user requirement and allocate them in cluster form to the available data centers. This approach helps to improve the performance of CPU and memory.

In [22], the authors present an overview of Cloud and Services offered by the Clouds. It also gives a review of various VM Migration policies.

[25] Uses two host selection policies and four First-Fit mapping heuristics for the power aware allocation for VMs.
Simulations performed showed that the four power aware algorithms help to lower the energy consumption on the hosts.

In [28], the Maximum and Minimum Frequencies DFVS (MMFDVFS) algorithm is presented. The algorithm helps to reduce the energy consumed by the processors. An optimal energy consumption formula is modeled in this paper. The linear combination of them in processor frequency and max processor frequency is used to find out the optimal consumption of energy. But, this method can be used only in homogeneous systems and not in heterogeneous systems.

IV. ENHANCED DVFS

Implementation of DVFS is shown below with the help of a flow chart:

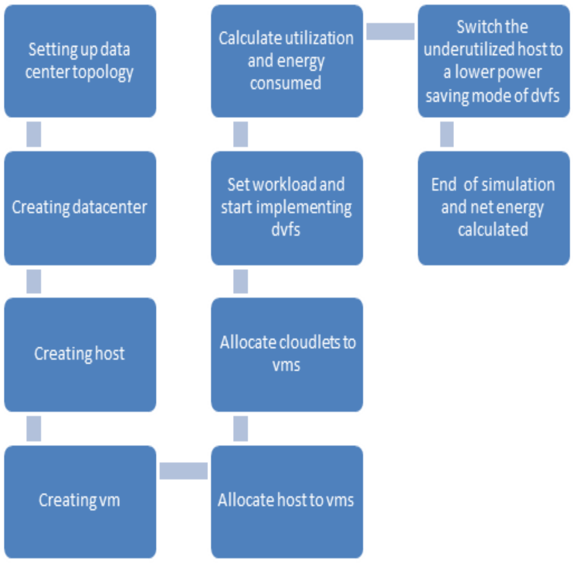

Fig 2 Flow chart showing Implementation of DVFS

Various Steps involved in the implementation of DVFS

The steps in DVFS Implementation are stated below:

- *Initializing cloud*: creating the data center network topology i.e determining the number of servers and switches and their interconnections. This is done in the topology .tcl file
- *Create a data center*: It is the second step in the simulation of a cloud infrastructure.. To create

datacenter we need to create hosts. The number of hosts can vary with the simulations. For each host we need to define the number of processors and their MIPS rating .i.e. Millions of instructions processed per second. After virtual machines are created by using the inbuilt class Vm. Vm class accepts a list of Vms. Each Vm has specifications like, MIPS, size, ram, bandwidth, number of processing elements and the Cloudlet scheduling policy. We are going to GREEN scheduling algorithm. Once the virtual machines and the hosts have been created, the next step is to allocate the virtual machines to the host. The scheduling policy of virtual machines is specified while creating the host. The scheduling of virtual machines on the hosts can be either time shared or space shared depending on the policy we are implementing.

- *Allocate cloudlets to the virtual machines:* Next the cloud tasks .i.e. cloudlets are allocated to the virtual machines. The number of user and behavior of cloud user is determined in the user .tcl file.
- *Set load:* After allocating cloudlets to vms we set workload which should lie from 0 to 1

The next step would involve calculating utilization and energy consumed at the end of each time frame*:* The time frames or time slots are defined before starting the simulation. The underutilized host are detected

- Switch off the under-utilized host to lower power saving modes: The energy saving algorithm that we are implementing here is DVFS. This policy checks after each time frame whether any host has utilization less than the average workload set in the previous step. If any such host is found .that host is send on the power saving mode of DVFS. DVFS also has a provision according to which, a host with 0% utilization is turned off to save the energy[18].
- Calculate net energy: At the end of simulation, calculate the net energy consumption of the datacenter and number of host shutdowns.

We get the energy consumed by the servers, the energy of the switches(access switches, aggregation switches and core switches separately)

.

For the optimization of the DVFS algorithm ,we will apply power model while the allocation of vm to servers, so that the vm is intelligently allocated to an energy efficient server, which in turn will decrease energy consumption .Hence enhancing the performance of the DVFS algorithm

V. RESULTS

The simulation of a data center with three tier architecture, consisting of 144 servers ,6 switches(1 core ,2 aggregation,3 access switches) and one user on the green simulator with implementation of DVFS in a cloud gives the total energy consumption as 301.9W*h. The result of simulation is shown in Fig 3.

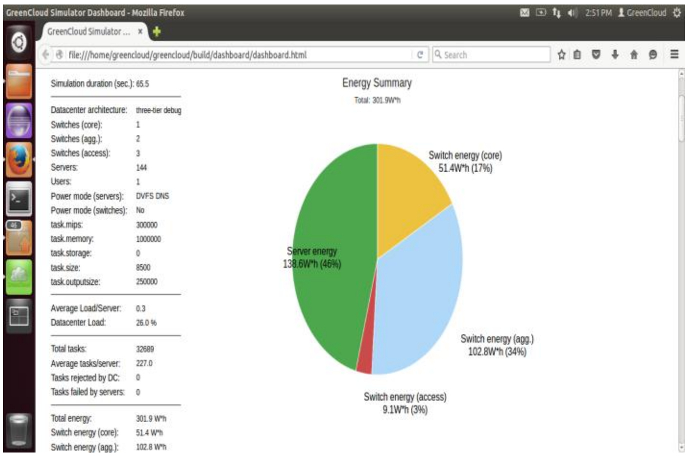

Fig 3 Simulation result of implementation of DVFS

In the attempt to enhance the performance of DVFS , we used various power models during the allocation of vms to the host. The power models intelligently allocate a vm to a energy efficient server which helps in reducing the power consumption of the data centers. Here we have applied and checked the performance of two different power models i.e Linear power model and low power model along with the dynamic voltage frequency scaling power management scheme .

The results of linear power model and low power blade model with DVFS and green scheduling algorithm using same configuration of the data center discussed earlier is shown below Fig 4 and Fig 5:

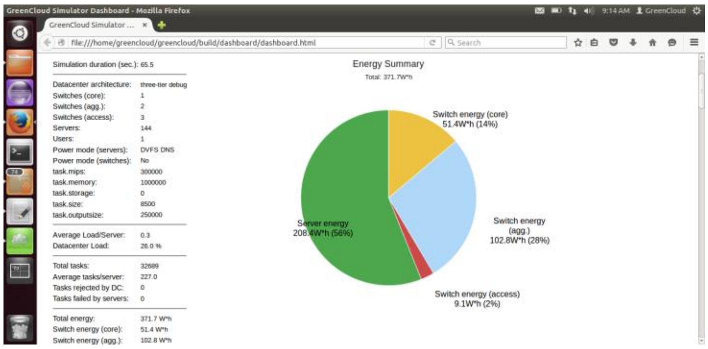

Fig. 4 Simulation result using Liner power model with DVFS

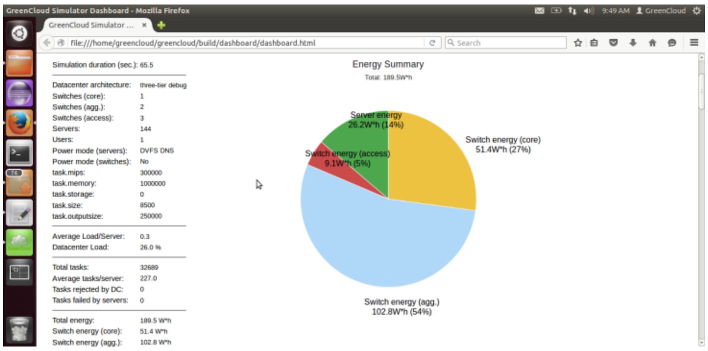

Fig 5 Simulation results using low power blade model with DVFS scheme

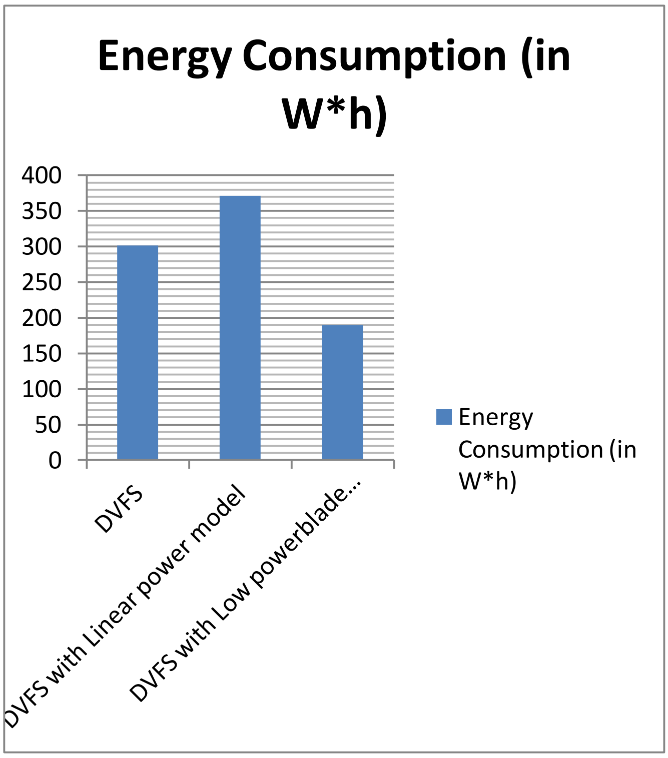

Fig .5.29 Graph of Total Energy consumption obtained in three different techniques

The graph show the total energy consumption of the three different simulation results, i.e. DVFS,DVFS with linear power model and DVFS with low power blade model. The vertical axis shows energy consumed in W*h ranging from 0 to 400 and the horizontal axis shows various simulations carried out. The net energy consumed in the three simulations is highlighted in the graph .It is clear from the graph that DVFS with low power blade model gives the best performance by consuming least amount energy .

The below graph shows the comparison of different workloads and total energy consumed.

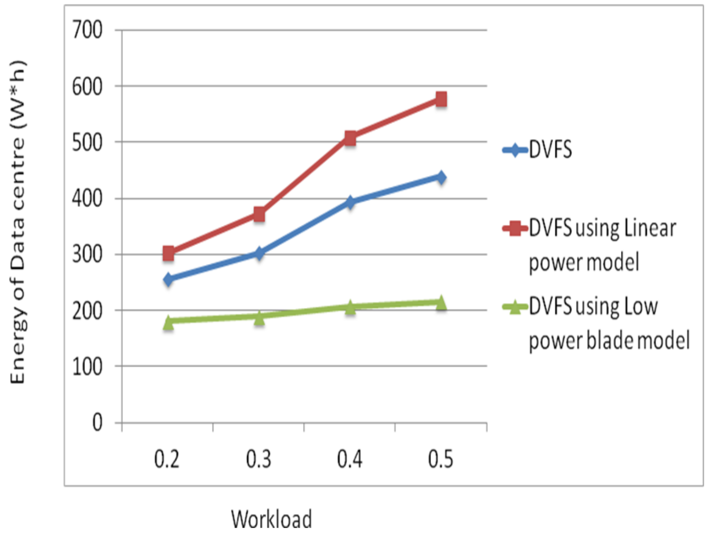

Fig.5.30 Graph of Workload and Total Energy

The graph shows the total energy consumption of the three techniques at varying average workload per server. It is obtained that DVFS with low power blade model gives the best result in all different workloads considered.

The below graph shows the comparison of different workloads and server energy.

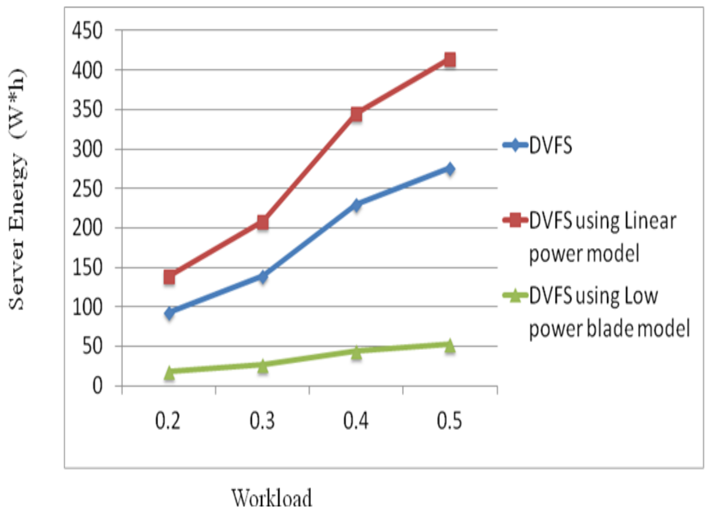

Fig.5.31 Graph of Workload and Sever Energy

This graph again confirms the efficiency of the Enhanced DVFS Techniques, i.e. the DVFS with low power blade model. The Graph shows that sever energy is least when low power blade model is used with DVFS.

VI. CONCLUSION

Cloud computing has grown so fast that it had made almost every organization rely on it. Since the time it had developed and now there is vast technological change in the field. It requires huge effort to build a technology that could help consumers as well as service providers. Currently we are facing energy as a challenge in the field of cloud. The cloud infrastructure not only consume electricity by itself it also need auxiliaries which also consumes electricity in order to keep the temperature down for these machines. The performance growth of computing systems has been limited because of energy consumption and carbon dioxide emissions.

In this paper we have evaluated the energy consumption by optimizing the DVFS algorithm using different power models. The low power blade model with DVFS has given a better result i.e. energy consumption dropped by 37% with same configuration of data center architecture which in turn will help in reducing carbon emission by upholding the overall system performance. Thus, this policy helps to improve the energy efficiency of the system.

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