Survey Paper on DVFS-based Power Aware Scheduling

Ms. Divya Kanani
Computer Engineering,GTU

ABSTRACT

In cloud computing, the energy aware scheduling problem has been a critical issue in high-performance clouds. High energy consumption leads to high CO2 emission. An existing technique Dynamic voltage and Frequency Scaling (DVFS) minimizes energy consumption for data center which will result in the less number of carbon footprints without compromising Quality Of Service (QoS). The goal of the proposed work is to reduce energy consumption while processing requests. DVFS allows host CPUs to dynamically change power state when resource demands are low to reduce a host's energy consumption. This survey paper discusses the various methods used to reduce energy consumption and scheduling algorithms in cloud computing.

Keyword:- *Cloud computing, Energy consumption, Bag- of-Task, Task Scheduling*

---

1. INTRODUCTION

Cloud computing is emerging large scale computing which has moved computing and data away from desktop and portable PCs, into large data centers. It provides the scalable IT resources such as applications and services, as well as the infrastructure on which they operate, over the Internet, on pay-per-use basis to adjust the capacity quickly and easily [7]. The National Institute of Standards and Technology (NIST) definition lists five essential characteristics of Cloud computing: on-demand self-service, broad network access, resource pooling, rapid elasticity or expansion, and measured service. By increasing demand of cloud infrastructure has also increased the energy consumption of data centers, which has become a critical issue in cloud computing. In order to obtain more energy reduction as well as maintain the quality of service (QoS) dynamic voltage and frequency scaling (DVFS) is used. DVFS is the adjustment of power and speed settings on a computing device's various processors, controller chips & peripheral devices to optimize resource allotment for tasks and minimize power saving when those resources are not needed. DVFS allows to dynamically adapting the machines performance to the changing condition of workload.

1.1 NEED FOR ENERGY SAVING IN CLOUD

Energy efficiency is increasingly important due to the increasing energy costs and there is need to reduce carbon emissions and overall energy consumption. IT industry contributes to 2% of worlds total CO2 emissions and a typical data centre consumes as much as energy as 25000 households. Servers consume 0.5% of the world's total electricity usage. More than 15% of the servers are running without being used actively [7]. So we need DVFS based energy aware scheduling methods to minimize energy consumption.

2. EXISTING TECHNIQUES FOR ENERGY EFFICIENCY

2.1 Improving Energy Efficiency Of Computing Servers And Communication Fabric In Cloud Data Centers[1].

Cloud Computing has threat of high energy consumption from both computing servers and communication fabric. Most of the existing work for reducing Data Center energy consumption is focused at computing servers only. The goal of the proposed work is to minimize the energy consumption at both computing servers and communication devices. Enhanced weighted Dynamic Voltage Frequency Scheduling Algorithm(DVFS) for assigning tasks to virtual machine is implemented for minimizing energy consumption of the computing servers.

The aim of the proposed work is to reduce energy consumption when processing requests using energy aware Data Center allocation algorithm and enhanced weighted DVFS technique is implemented in assigning tasks to virtual machine to further reduce the energy consumption.

Power Consumption of Server at Load 1 is calculated using Formula

$$P_s(l) = P_{idle} + \frac{P_{Peak} - P_{idle}}{2}\left(1 + l - e^{\frac{1}{a}}\right) \quad [1]$$

Energy Consumption of Virtual Machine is calculated

$$\mathrm{P}(\mathrm{VM_i}) = \frac{\mathrm{P_{idle}}}{\mathrm{N}} + \sum_{\mathrm{j}\in\{\mathrm{cpu,ram,disk}\}} \mathrm{k_j x U_j} \quad [1]$$

Assign VM to Task by Calculatig the Weight of Each Task

This is done by calculating Weight of Each VM.

$$\mathrm{Wi} = \mathrm{Pi*Ri} \quad [1]$$

Where Pi is power of cost of server/vmi and

Ri is Resource used by server/Vm(i)

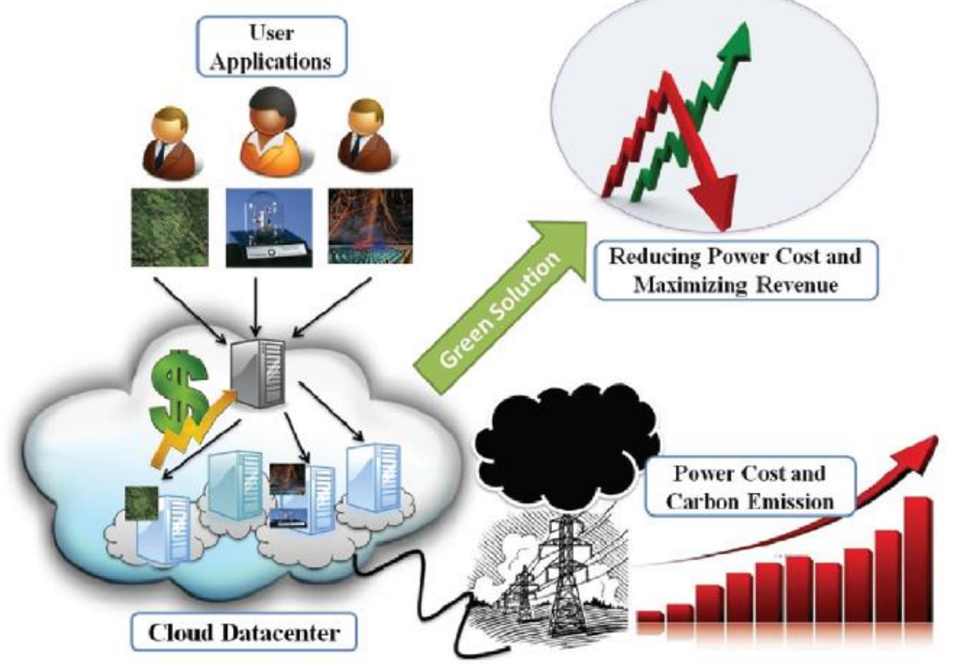

Fig. 1. Energy Aware Data Center Selection Mechanism[1].

Algorithm 1 describes the steps used in the proposed system for management of cloud computing service request based on current availability of renewable energy. When the task is submitted by the user, after VM allocation is over the Data Center powered by renewable energy is selected. Only when the Data Center (DCs) powered by renewable energy is unable to process a user request it goes to DC powered by conventional energy (fossil fuel).The use of DCs powered by renewable energy results in low amount of CO2 emission.

Algorithm 1 Data Center Selection algorithm

Input :Data center Set,Host Set,VM set and Task set
Output:Allocation of Task to VM and Data Centre Selection
Read cloudlet Data
Read Task details of workflow
for all T_i in T **do**
  for all DC in DC_List **do**
    if DC_wind_power is available **then**
      Selected_DC=DC_wind_power
    else if DC_solar_powere is available **then**
      Selected_DC = DC_solar_power
    else
      Selected_DC=DC_fossil_fueL_power
    end if
  end for(Data Center)
end for(Task)
for all VM in $VM[]$ **do**
  $VM[i]\_fmax = fmax$
  $VM[i]\_fmin = fmin$
  $Wi = Pi * Ri$
end for(VM)
Sort all the VM based on Weight Wi value
Map the task to the VM with highest Weight value

The use of DVFS results in reduced energy consumption as the voltage at which a particular host is varied depends upon the frequency of the given task. Tasks with lower frequency are completed at a lower voltage and vice versa.

The proposed system provides the better results in reducing the energy consumption of the resources but also reducing the CO2 emission by using data center powered by renewable resources.

2.2 Dynamic Real-Time Scheduling with Task Migration for Handling Bag-of-Tasks Applications on Clusters[2].

The scheduling of real-time tasks on clusters is a critical issue for offering quality-of-service (QoS) assurance. In this paper we focus on the scheduling of bag-of-tasks (BoT) applications consisting of many independent tasks. We propose a dynamic (online)real-time scheduling algorithm referred to as scheduling algorithm with migration (SAM) for handling real-time BoT applications on cluster systems. SAM schedules tasks to the minimum number of processors so that computation power can be saved for unscheduled large tasks. SAM also utilizes task migration to optimize load balancing without undermining the schedulability of the tasks.

Real-time scheduling algorithms generally fall into two categories: static (off-line) ,and dynamic (on-line). static algorithms cannot be utilized to handle aperiodic real-time tasks whose arrivals are unexpected. Scheduling such tasks requires dynamic algorithms which dynamically admit and schedule new tasks without compromising the guarantees for previously admitted tasks.

To solve the scheduling problem, we design the SAM algorithm, which is shown in Algorithm 1. SAM consists of two steps. In step 1, SAM first allocates loads to the minimum number of processors so that computation power can be reserved to unscheduled large tasks. Then in step 2 task migration is applied to optimize load balancing. To schedule a selected task, SAM first schedules the largest sub-task among all unscheduled sub-tasks of the BoT task. SAM allocates the sub-task to the processor on which the latest completion time before the deadline can be achieved. By doing so, computation power can be saved for unscheduled big tasks.

However, using the minimum number of processors may lead to poor load balancing, which may reduce the schedulability of future tasks. In this case we use task migration to optimize resource utilization. Once all tasks are successfully scheduled in step 1, task migration will be executed in step 2 to enhance resource utilization.

In this paper we have studied an important problem of scheduling real-time BoT applications on clusters. We have proposed the SAM algorithm which utilizes task migration to optimize resource utilization.

2.3 DVFS-Aware Consolidation for Energy-Efficient Clouds[3]

Nowadays, data centers consume about 2% of the worldwide energy production. Cloud providers need to implement an energy-efficient management of physical resources in order to meet the growing demand for their services. The main strategies for energy-efficiency in Cloud data centers: Dynamic Voltage and Frequency Scaling (DVFS) and Consolidation.

Dynamic Voltage and Frequency Scaling (DVFS) helps to reduce the consumption of underutilized resources dynamically, while consolidation strategies decrease significantly the static consumption by reducing the number of active servers, thus increasing their utilization.

The proposed algorithm is based on a bin packing problem. This approach minimizes the number of bins used while taking full advantage of the range of CPU utilization available for each frequency. The algorithm speeds up consolidation and the elastic scale out of the IT infrastructure, presenting a global utilization increase of up to 23.46% by reducing the number of active hosts by 44.91**% (see fig 2).**

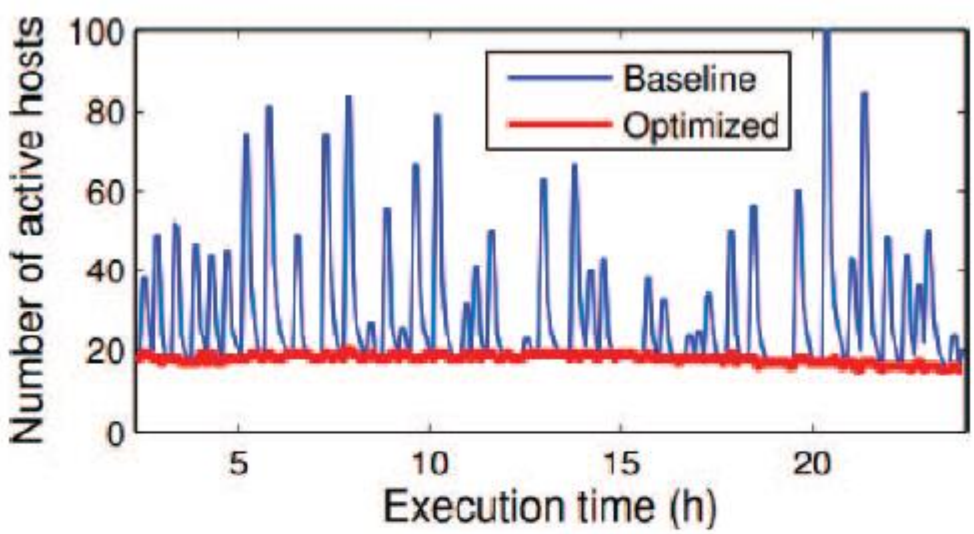

Fig. 2. Number of active hosts during runtime[3].

2.4 Dynamic Voltage and Frequency Scaling based Parallel Scheduling Scheme for Video Recognition on Multicore Systems[4]

The video recognition on computer systems has become a high computing complexity and consumed the enormous amount of energy. This paper uses DVFS power management technique schedules the frame task to cores with higher or lower VF settings depending on a task's time-varying compute intensity. The proposed scheme can further improve the energy consumption by 9% to 16% with great speedup.

Today, the increasing popularity of multimedia applications, which are typically associated with higher computing complexity and, thus, consume more power, has prompted efforts to conserve the battery power of portable devices. The video recognition on computer systems has become a high computing complexity and consumed huge amount of power.

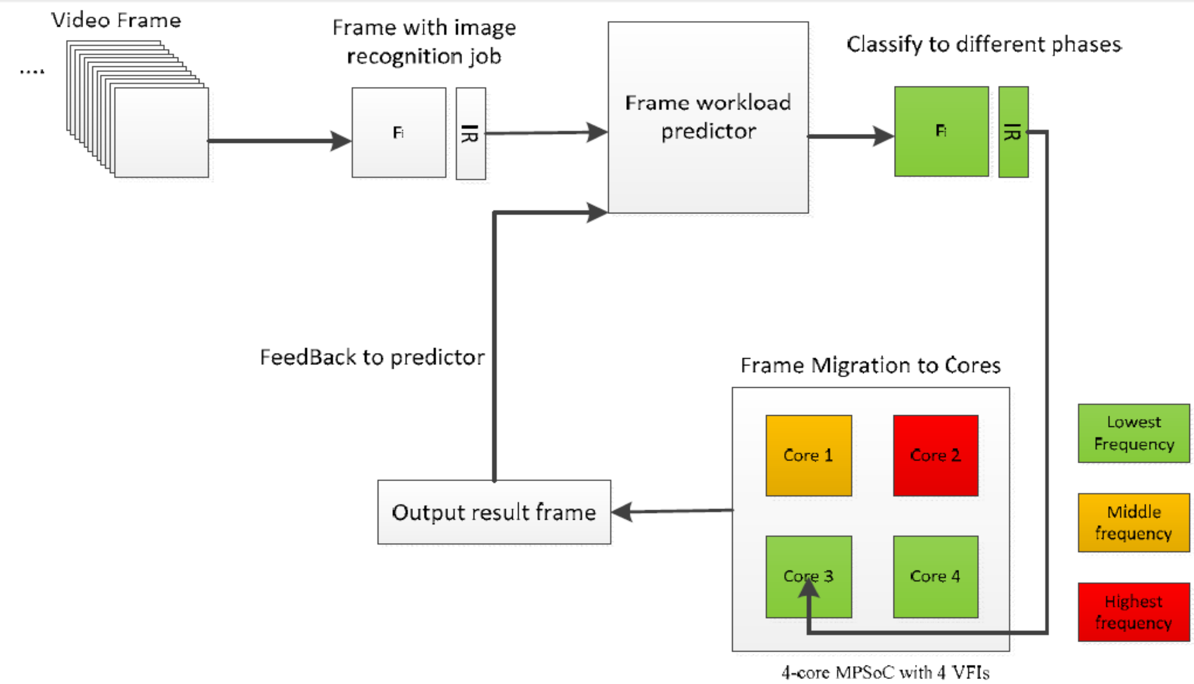

Fig. 3. DVFS based parallel scheduling [4].

As shown in Fig., the proposed DVFS scheme divided the video recognition into one frame with image recognition task and frame workload predictor predicts the system workload of the frame task. After predicting the frame workload, the DVFS scheme classifies the frame task to different phases to supply a minimal voltage and frequency without performance degradation. Final, the DVFS scheme migrate the frame task to the core with an appropriate CPU frequency. Compared to the conventional DVFS schemes incur a large voltage and frequency transition delay, the proposed DVFS scheme reduce the number of voltage and frequency adjustments. The proposed DVFS power management with frame migration offers two important benefits: (1) it saves a large voltage and frequency transition delay to arrive at the target core with proper CPU frequency. The DVFS transition delay is due to off-chip voltage regulators that limit how quickly voltage can change, and the frequency transition delay comes from PLL relock times; (2) the DVFS scheme also provide a good quality parallel scheduling on load balancing for the video recognition.

2.5 CloudFreq: Elastic Energy-Efficient Bag-of-Tasks Scheduling in DVFS-enabled Clouds[5]

Many studies explore the opportunities to save power by energy-efficient task scheduling based on the technique of dynamic voltage and frequency scaling (DVFS). This paper proposes an elastic energy-efficient algorithm called CloudFreq for bag-of-tasks scheduling in DVFS-enabled clouds. Cloud- Freq enables a model of elastic, adjustable energy-efficient scheduling without any prior knowledge of constraints, and then eliminates job rejections accordingly. CloudFreq also provides an entry for operators to scale system performance at runtime.

First, the maximum and minimum finish time are acquired by traversing Time matrix while the maximum and minimum energy consumption are gained by traversing Energy matrix Second, EST matrix is organized as Time and Energy matrices and each element involves considerations on execution time, energy consumption and weights of them. Third, the task with minimum EST is selected by traversing EST matrix, and the corresponding Xki;j is appended to the resulting set X. Fourth, since the selected task has been scheduled on the candidate processor, the remaining tasks will be delayed in that processor, so Time matrix is updated by adding the execution time of the selected task to related elements

It achieves both time-based and energy-based goals by self-iteration instead of being guided by constraints.

3. CONCLUSIONS

Energy consumption in cloud Data Center is the growing concern in cloud platform. Scheduling of tasks to the virtual machine by assigning weight values based on the minimum number of resources required is proposed in this paper. To further reduce the energy consumption DVFS technique is used to control the supply voltage and frequency for servers. Not only the proposed system provides the better results in reducing the energy consumption of the resources but also reducing the CO2 emission by using data center powered by renewable resources.

4. REFERENCES

[1] Soma Prathibha, B.Latha and G.Sumathi. " Improving Energy Efficiency Of Computing Servers And Communication Fabric In Cloud Data Centers" Second international conference on research in computational intelligence and communication networks(ICRCICN),(2016).

[2] Menglan Hu and Jun Luo. " Dynamic Real-Time Scheduling with Task Migration for Handling Bag-of-Tasks Applications on Clusters" IEEE,(2012).

[3] Patricia Arroba, José M. Moya, José L. Ayala and Rajkumar Buyya. " DVFS-Aware Consolidation for Energy-Efficient Clouds" International Conference on Parallel Architecture and Compilation,IEEE(2015).

[4] Yen-Lin Chen, Ming-Feng Chang and Wen-Yew Liang. " Dynamic Voltage and Frequency Scaling based Parallel Scheduling Scheme for Video Recognition on Multicore Systems" International Conference on Consumer Electronics-Taiwan ,IEEE,(2016).

[5] Yujian Zhang, Yun Wang and Cheng Hu. " CloudFreq: Elastic Energy-Efficient Bag-of-Tasks Scheduling in DVFS-enabled Clouds", 21st International Conference on Parallel and Distributed Systems IEEE,(2015).

[6] Delforge, P., and J. Whitney. "Issue Paper: Data Centre Efficiency Assessment Scaling up Energy Efficiency Across the Data Centre Industry: Evaluating Key Drivers and Barriers." Natural Resources Defense Council (NRDC), Tech. Rep (2014).

[7] Vinisha Sasidharan and P. Mohamed Shameem. " Survey on Energy Efficient Resource Allocation Methods in Cloud Environment" International Conference on Innovation in Communication, Information and Computing (ICICIC) 2013.

[8] K. Ramamritham, J.A. Stankovic, and P.F. Shiah, "Efficient Scheduling Algorithms for Real-Time Multiprocessor Systems," *IEEE Trans. Parallel and Distributed Systems*, vol. 1, no. 2, pp. 184- 194, Apr. 1990.

[9] A. Beloglazov and R. Buyya, "Optimal online deterministic algorithms and adaptive heuristics for energy and performance efficient dynamic consolidation of virtual machines in cloud data centers," Concurr. Comput. : Pract. Exper., vol. 24, no. 13, Sep. 2012, pp. 1397–1420.

[10] Wen-Yew Liang, Ming-Feng Chang, Yen-Lin Chen, and Chin-Feng Lai, "Energy Efficient Video Decoding for the Android Operating System," *in Proc. of the IEEE International Conference on Consumer Electronics (ICCE 2013),* Las Vegas, NV, United States, January 2013.