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Comparative Analysis of Energy Efficiency Algorithms for Cloud Datacenters

Kritika Sharma*
M.Tech Student, Department of Computer Engineering,
Punjabi University, Patiala, Punjab, India

Raman Maini
Professor, Department of Computer Engineering,
Punjabi University, Patiala, Punjab, India

Abstract— ***Cloud Computing provides many services to its users. For this the Cloud providers install very large datacenters. But these datacenters consume an enormous amount of electrical energy. This becomes expensive in terms of money as well as environmental degradations. Thus, there is a need to lower the power consumption in the datacenters. In this paper, we implement a policy that uses minimum migration time as VM selection policy in place of power aware VM selection policy and compare it with existing BFDP algorithm as well as with the non power aware datacenter. The policy is simulated on the CloudSim toolkit and it is verified that the policy using minimum migration time provides energy efficiency without compromising with the system performance.***

Keywords— Cloud computing, virtualization, VM migrations, energy consumption, energy efficiency.

I. INTRODUCTION

Cloud Computing is an advanced technology which is used to provide various computing resources in the form of services through an internet connection. The users have only to pay for services that they are using. Cloud Computing is mainly based on the virtualization technology.

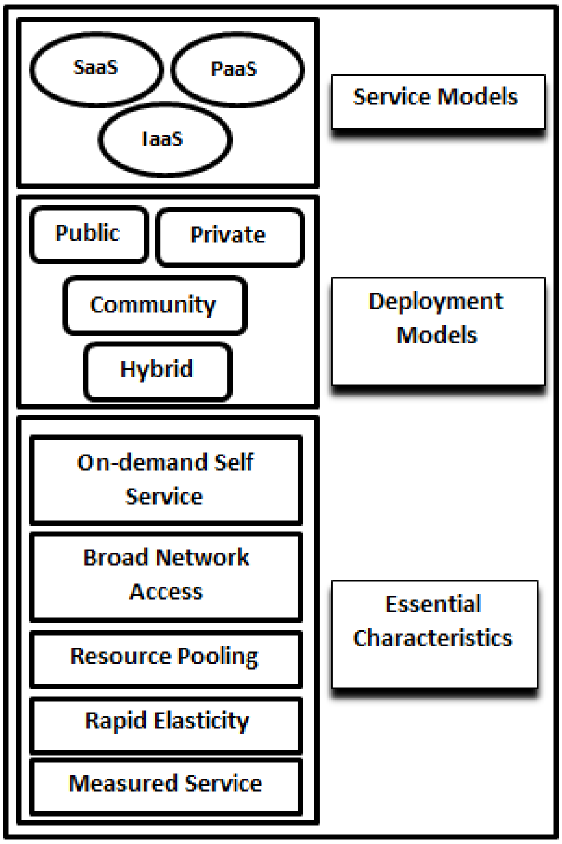


Fig. 1 NIST Definition of Cloud Computing

NIST provides the following definition of Cloud Computing: Cloud Computing model provides five characteristics that are very essential, four models of deployment and three service models [22].

The five very essential characteristics are availability of services, large network access, scalable, on-demand access, independence of location. There are four deployment models of Clouds: public, private, community, and hybrid Clouds.

The public clouds are those in which Cloud infrastructure is available to general public. The private Clouds are maintained and used by some private organisation or individual. The community Clouds are created to fulfil the needs of a community as a whole and the hybrid Clouds are combination of both public as well as private Clouds. In such Clouds all the sensitive information is kept in the private Clouds and the rest of the information is stored in the public Clouds.

The three service models of Clouds are: SaaS, PaaS, and IaaS. SaaS means Software as a Service. The end users use SaaS for using the existing online applications. These applications are managed by the Cloud providers. PaaS means Platform as a Service. The users of this model are developers. Developers use the platform provided by the PaaS providers to develop any of their applications. Managing and updating the development platform is the sole responsibility of the PaaS provider. IaaS means Infrastructure or Hardware as a Service. IaaS provides the physical server instances to its customers. The customers have to pay for the time for which they have used the IaaS services.

To provide all these services, a large number of nodes have to be installed. These large number of computing nodes consume a lot of electric energy. This raises the expenditure for the Cloud providers. It has been found that the energy consumption cost for the datacentre is much greater than the overall IT cost. The huge energy consumption is not only expensive but it also has the harmful effects on our environment as it leads to high CO_2 emission.

To reduce the power consumption in datcenters any one of the following can be followed [16]:

- Utilizing hosts to the maximum by creating virtual machines on them.
- Converting the idle hosts to the power saving modes or turning off the idle hosts.
- Optimizing VM allocation by live VM migrations.

Many efforts have been taken to make datacenters energy efficient. But most of them have to compromise with the system performance. In this paper, we will discuss a strategy that will reduce energy consumption by keeping the SLA violations to the minimum. We will compare this strategy with the one given in [5]

Section II of the paper gives details about the related work. Section III describes the steps for optimizing energy consumption in Cloud datacenters. Section IV gives an overview of the simulator used to conduct simulations. Section V explains simulation environment. In section VI for results are discussed. Section VII gives the conclusion.

II. RELATED WORK

In [4], the author has proposed architecture for energy efficiency in Clouds. It also proposed an energy efficient a resource allocation strategy which is validated on the CloudSim simulator. The paper also addresses various open research challenges.

In [5], the authors have focussed on explaining the Cloud model. Competitive analysis of various virtual machine migration algorithms have been conducted. They have also explained various utilization thresholds, vm placement and vm migration policies.

[6], proposed a resource provisioning strategy to provide the specified quality of service. The proposed strategy has been tested using the real life workload traces.

In [17], the author has proposed a new algorithm called Best Fit Decreasing Power. The proposed algorithm helps in reducing the power consumption of a datacentre with homogeneous nodes while meeting all the quality of service requirements. The proposed scheme is simulated on CloudSim and it has been found that the proposed strategy helps to reduce the power consumption of a datacenter.

In [23], Adaptive Power-Aware Virtual Machine Provisioner is proposed. It is a meta scheduler that minimises the power consumption. This strategy helps to reduce the energy consumption to a great extent.

[26] proposes a three phase strategy for saving energy. this three phase strategy is based on replica management. This strategy saves energy at three different levels. This has helped to increase the system adaptability. The strategy is tested on the CloudSim simulator.

[27], reviews various load balancing policies among various computing nodes. All the load balancing policies have been studied in detail and their advantages and disadvantages have been listed.

In [28], the authors describe the energy aware solutions that are needed to be implemented so as to support energy efficiency. The work basically focusses on DVFS implementation in the CloudSim simulator.

III. OPTIMIZING ENERGY CONSUMPTION

Once the initialization of the datacenters is done and all the cloudlets are submitted to the VMs, the next step is optimization of the datacentre. To optimize the energy consumption in Clouds the VM placement and reallocation have to be optimized. VM optimization covers following four steps [5]:

i. Detecting the over utilized hosts
ii. Selecting the VMs to be migrated
iii. Selecting the hosts to which VM has to be migrated
iv. Detecting the underutilized hosts

i. Detecting the over utilized hosts: Over utilized hosts lead to more SLA violations, thus leading to degrade system's performance. Thus we need to detect all those hosts that are over utilised and reduce its load. To detect the over utilized host, an utilization threshold is fixed. Then this value is used to calculate the upper threshold to detect an over utilized host. The utilizations thresholds discussed here are: MAD, IQR and THR. These thresholds are discussed as follows:

- *MAD:* MAD or Median Absolute Deviation is a robust measure and is used in statistical dispersion. MAD is used to calculate dispersion. Let us consider univariate data, $Y_1, Y_2, Y_{3 \ldots\ldots}, Y_n$, the MAD of this data is median of all the deviations from the median of the data, and these deviations are the absolute deviations.[5]

$$MAD = median_k(\left| Y_k - median_l(Y_l) \right|) \qquad (1)$$

The Utilization Threshold is calculated as"

$$Utilization\ Threshold = 1 - s \,.\, MAD \qquad (2)$$

Here, *s* is the safety parameter which is a positive real number. If value of *s* is low, it means the energy consumption is lower but SLA violations are higher. [5].

- *IQR*: Inter Quartile Range is also a measure of statistical dispersion. IQR is equal to third quartile minus first quartiles [5].

$$IQR = Q_3 - Q_1 \qquad (3)$$

The value of Utilization Threshold is calculated as: [5]

$$Utilization\ Threshold = 1 - s \,.\, IQR \qquad (4)$$

where, *s* is the safety parameter.

- *THR*: The static threshold policy considers a static threshold value to generate utilization thresholds. This value is used to generate Utilization Threshold [5].

The value of Utilization Threshold is calculated as: [5]

$$Utilization\ Threshold = 1 - s \,.\, THR \qquad (5)$$

where, *s* is the safety parameter.

On conducting simulations for these utilization thresholds under same conditions, it is concluded that out of all three parameters, IQR gives the best results for energy efficiency and gives the lowest SLA violations. Thus we will be using IQR for our implementation.

ii. Selecting the VMs to be migrated: Once we have determined that the host is over utilized, next we have to select the VMs to be migrated from this host. Migrating these VMs away to some other host help to reduce the load from the over utilized host. The policy that we have chosen here to migrate the VMs is Minimum Migration Time Policy. That is, we choose that VM from the over utilized which will take minimum time to migrate to some other host.

The MMT policy finds a VM v that satisfies the following condition [5]:

Let *a* is some host. V_a is the set of all VMs deployed on *a*,

$$v \in V_a \;\middle|\; \forall p \in V_a, \frac{RAMu(v)}{NET\,a} \leq \frac{RAMu(p)}{NET\,a} \qquad (6)$$

where $RAM_u(p)$ is the amount of RAM currently utilized by the VM *p*; and NET_a is the spare network bandwidth available for the host *a* [5].

iii. Selecting the hosts to which VM has to be migrated : MMT selects the VM to be migrated. Next we need to select a host where we can place this VM. For this we determine the power consumption of each host after allocating this VM to it. Then we calculate the power difference:

Power difference = Power after allocation – power before allocation (7)

The host for which the difference between power after allocation and power before allocation is the minimum is selected and VM is migrated to this host.

iv. Detecting the underutilized host: Here, we choose that host which has the lowest utilization. All the VMs that are deployed on the host are migrated using MMT to some other host by using policy given in *iii*. The hosts that are switched off, over utilized or those chosen in *iii* are excluded from the list of underutilized hosts.

We implement this policy and compare it with Best Fit Decreasing Power [5]. Best Fit Decreasing Power(BFDP) is the policy that differs in *ii* from our policy. BFDP uses a power aware VM selecting policy. That is, that VM is selected to be migrated which gives lower power consumption results when it is migrated to some other host.

IV. CLOUDSIM SIMULATOR

We are using CloudSim simulator to implement and test the above policy. CloudSim is written in Java. It provides inbuilt classes to simulate the Cloud environment on a single computing node. Since a Cloud environment consists of large number of nodes, so it gets impossible to build an actual Cloud and test our suggested policy on it. Thus CloudSim provides a very suitable simulation environment to test our suggested policies.

The architecture of CloudSim (Fig 2) includes four layers: SimJava, GridSim, CloudSim, UserCode. SimJava is the lowermost layer. It performs all the core activities like communication between entities. The GridSim layer model the infrastructure of grids. The CloudSim layer performs the actual implementation of the CloudSim simulator. The topmost layer, UserCode contains information like no. of hosts, no. of users, etc.

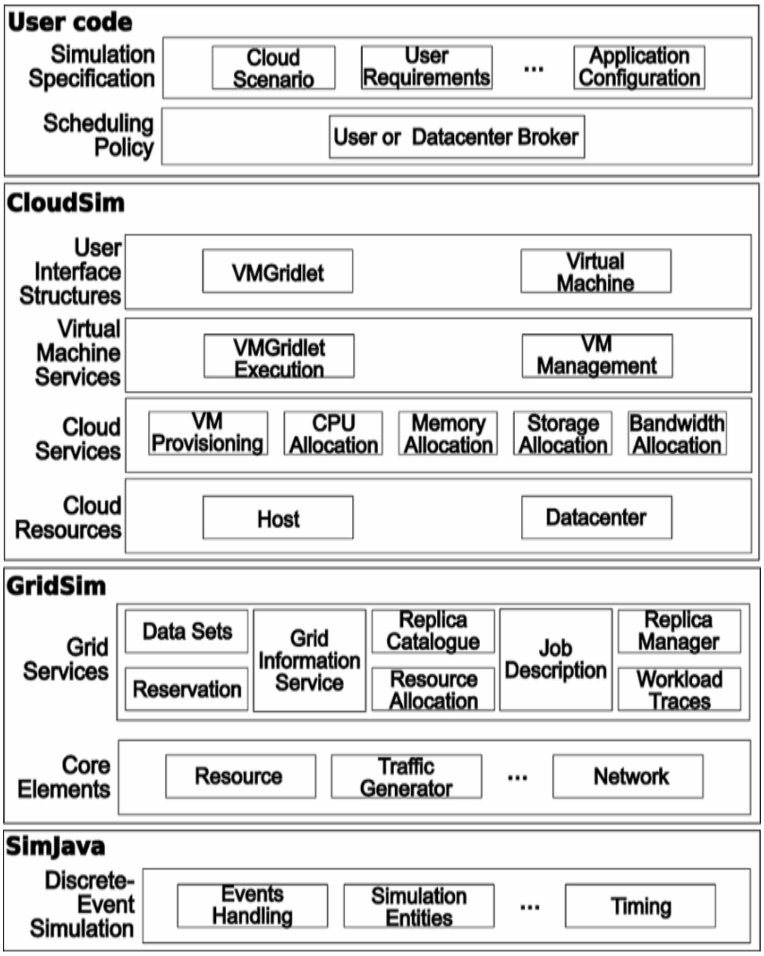


Fig. 2 Layered CloudSim architecture[25]

The CloudSim simulator consists of various inbuilt classes that are used to simulate a Cloud environment. Some of the inbuilt classes of CloudSim are:

- Datacenter
- PowerDatacenter (derived class of Datacenter, used for determining power consumption)
- DatacenterBroker
- PowerDatacenterBroker (derived class of DatacenterBroker, used for determining power consumption)
- Vm
- PowerVm (derived class of Vm, used for determining power consumption)
- PowerModel
- CloudletScheduler
- VmScheduler,

and many more. Datacenter class helps to simulate Cloud datacentre. PowerDatacenter is the derived class of Datacenter, it includes methods that help in estimating power consumption of the datacentre. Similarly, PowerVm, PowerDatacenterBroker, have power estimation features.

Quantitative parameters that we are using to compare the two policies are:

- *Energy consumption:* Linear interpolation function gives the energy consumption of the datacenter.

$$Energy\ Consumption = previousPower + \ (\ presentPower - previousPower\ )/2\ )\ *\ time \qquad (6)$$

Here,
*previousPower :*power consumed due to previous CPU utilization
presentPower : power consumed due to present CPU utilization
time : is the time difference between the current time and last process time

The power is calculated using the getPower() method. This method calculated the power consumption for the CPU utilization using the pre-defined system model.

- *SLA Violations:* SLA stands for Service Level Agreement. Any violations Service Level Agreement leads to lower performance of the system. If the requested processing power is not delivered to the customer, we get SLA violations.

$$SLA\ violations = (SLA\ per\ active\ host + SLA\ degradation\ due\ to\ migration\ )\ *\ 100 \qquad (7)$$

Here,

SLA per active host: is the sum of all the violations for all the hosts when allocated mips is less than requested mips.

SLA degradation due to migration: is the sum of all the violations when VM cannot be allocated to a host because of VM migration

We worked on NetBeans IDE 8.0.2 to run the java classes and implement the simulations.

V. SIMULATIONS

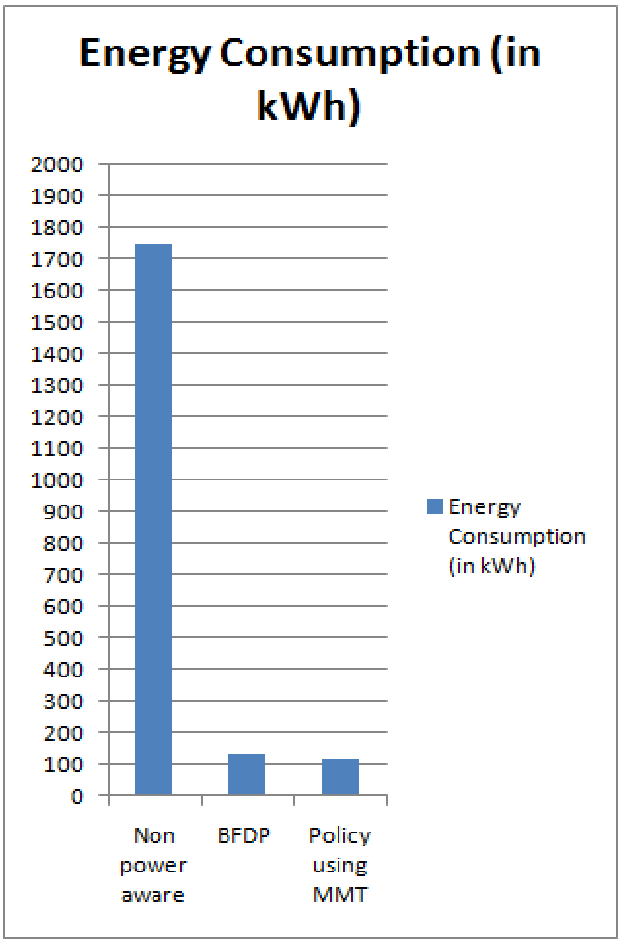
We have used CloudSim version 3.0.1 to simulate the Cloud. We have created 1000 homogeneous hosts. Each host has storage of 1 GB and bandwidth equal to 1 Gbit/s. For 1000 hosts we have 1052 VMs. Each VM has bandwidth of 100 Mbit/s and size of each VM is 2.5GB. Each VM requires only one processing core. We have conducted simulation for three types of datacenters: a datcenter that uses no energy optimization technique, a datcenter that uses BFDP for energy efficiency and, a datcenter that uses the policy using MMT. On conducting the simulation for same Cloud environment and for same workload for all the three policies, we get the following results.

TABLE I SIMULATION RESULTS

	Non-power aware	BFDP	Policy using MMT
No. of hosts	1000	1000	1000
No. of VMs	1052	1052	1052
Energy consumption (in kWh)	1743.00	136.85	114.68
Sla violations (in %)	0.0	0.00559	0.00346
No. of VM migrations	0	20625	16332

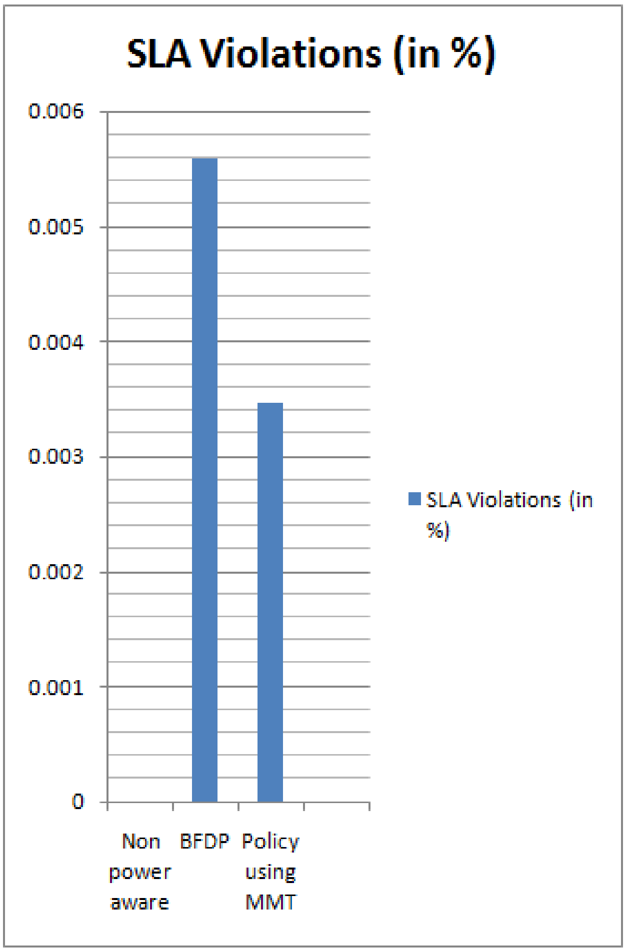
VI. RESULTS AND DISCUSSIONS

Table I shows that the results of the simulations conducted for all the three policies. The energy consumption for non power aware datacenter is very high. It is 1743.00 kWh. There us no VM migration thus 0% SLA violations in a non power aware datacenter. For BFDP gives energy consumption is 136.85 kWh. The SLA violations due to BFDP are 0.00559 %. Both these values are high in comparison with the policy that uses MMT VM selection policy. For the policy that uses MMT the energy consumption is 114.68 kWh and the SLA violations are 0.00346 %. The graphs for energy consumption for all three policies is given below (Graph I):



Graph I.

Following graph (Graph II) shows SLA Violations for all the three policies.



Graph II.

VII. CONCLUSION

The simulation results show that for the same configurations of datacenter and for the same workload energy consumption is maximum for a datacenter that is non power aware. This is evident that an energy optimization algorithm is very necessary to reduce power consumption in datacenters. The simulation results for the other two policies show that the policy using MMT gives lower energy consumption and lesser SLA violations than the BFDP policy. Thus, this policy helps to improve the energy efficiency of the system without compromising with the system performance.

REFERENCES

[1] Abhishek Goel, Shikha Goel, "Security Issues in Cloud Computing," International Journal of Application or Innovation in Engineering & Management (IJAIEM), vol 1, Issue 4, December 2012.

[2] Aditi Mahajan, Anita Ganpati, A Study of Energy Efficiency Techniques in Cloud Computing. IJCSMC, Vol. 3, Issue. 8, August 2014, pg.707 – 712

[3] Amritpal Singh, Supriya Kinger, Virtual Machine Migration Policies in Cloud, International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064 Volume 2 Issue 5, May 2013

[4] Anton Beloglazov, Jemal Abawajy, Rajkumar Buyya, Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing, Future Generation Computer Systems 28 (5) (2012) 755–768.

[5] Anton Beloglazov_ and Rajkumar Buyya, Optimal Online Deterministic Algorithms and Adaptive Heuristics for Energy and Performance Efficient Dynamic Consolidation of Virtual Machines in Cloud Data Centers , CONCURRENCY AND COMPUTATION: PRACTICE AND EXPERIENCE Concurrency Computat.: Pract. Exper. 2012; 24:1397–1420

[6] Bahman Javadi, Jemal Abawajy, Rajkumar Buyya, Failure-aware resource provisioning for hybrid Cloud infrastructure, J. Parallel Distrib. Comput. 72 (2012) 1318–1331

[7] Bhupendra Panchal, Prof. R. K. Kapoor, Dynamic VM Allocation Algorithm using Clustering in Cloud Computing, International Journal of Advanced Research in Computer Science and Software Engineering Volume 3, Issue 9, September 2013 ISSN: 2277 128X

[8] Buyya R, Yeo CS, Venugopal S, Broberg J, Brandic I. "Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility." Future Generation Computer Systems 2009; 25(6):599–616

[9] cloudsim 3.0 API [Online]. Available: http://www.cloudbus.org/cloudsim/doc/api/overview-summary.html

[10] Cyril Onwubiko, “Security Issues to Cloud Computing,” in Cloud Computing: Principles, Systems and Applications, Computer Communications and Networks, DOI 10.1007/978-1-84996-241-4_16, © Springer-Verlag London Limited 2010

[11] Hetal Joshiyara, Energy Efficient Provisioning of Virtual Machines in Cloud System using DVFS, INDIAN JOURNAL OF RESEARCH Volume : 3 | Issue : 4 | May 2013

[12] *Introduction to Cloud Computing* Office of Privacy Commissioner of Canada, 1989.

[13] Kevin Curran *et.al*., “Security Issues in Cloud Computing,” Copyright © 2012, IGI Global.

[14] Kevin Hamlen *et.al*., “Security Issues for Cloud Computing,” International Journal of Information Security and Privacy, April-June 2010.

[15] Kritika Sharma, Raman Maini, Cloud Computing and the Cloud Simulation, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 3 Issue 5, May – 2014.

[16] Kritika Sharma, Raman Maini,Comparative Analysis of Energy Efficiency in a datacenter using DVFS with a Non-Power Aware Datacenter (IJERT) ISSN: 2278-0181 Vol. 4 Issue 02, February-2015

[17] Liang Luo, Wenjun Wua, W.T. Tsai, Dichen Di, Fei Zhang, Simulation of power consumption of cloud data centers, Simulation Modelling Practice and Theory 39 (2013) 152–171

[18] Michael Armbrust *et.al.* “Above the Clouds: A Berkeley View of Cloud Computing,” Electrical Engineering and Computer Sciences University of California at Berkeley, Technical Report No. UCB/EECS-2009-28, February 10, 2009.

[19] NetBeans IDE Features [Online]. Available: https://netbeans.org/features/index.html.

[20] Nguyen Quang Hung, Nam Thoai, Nguyen Thanh Son, PERFORMANCE CONSTRAINT AND POWER-AWARE ALLOCATION FOR USER REQUESTS IN VIRTUAL COMPUTING LAB,

[21] Nikzad Babaii Rizvandi, Javid Taheri, Albert Y. Zomaya, Young Choon Lee, Linear combinations of DVFS-enabled processor frequencies to modify the energy-aware scheduling algorithms, in: Proc. of the 2010 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, 2010, pp. 388–397.

[22] Peter Mell,Timothy Grance, “The NIST Definition of Cloud Computing (Draft),” Computer Security Division, Information Technology Laboratory, National Institute of Standards and Technology ,Gaithersburg, January 2011.

[23] R. Jeyarani a, N. Nagaveni , R. Vasanth Ram, Design and implementation of adaptive power-aware virtual machine provisioner (APA-VMP) using swarm intelligence, Future Generation Computer Systems 28 (2012) 811–821

[24] Rajkumar Buyya, Anton Beloglazov, and Jemal Abawajy, Energy-Efficient Management of Data Center Resources for Cloud Computing: A Vision, Architectural Elements, and Open Challenges, 2010, CSREA Press

[25] Rodrigo N. Calheiros,. Rajiv Ranjan, Anton Beloglazov, C´esar A. F. De Rose and Rajkumar Buyya “CloudSim: a toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms”, CLOUDS Laboratory, Department of Computer Science and Software Engineering, The University of Melbourne, Australia , DOI: 10.1002/spe.995.

[26] Saiqin Long, Yuelong Zhao, Wei ChenSchool, A three-phase energy-saving strategy for cloud storage systems, The Journal of Systems and Software 87 (2014) 38– 47

[27] Sukhvir Kaur, Supriya Kinger, Review on Load Balancing Techniques in Cloud Computing Environment. IJSR, ISSN : 2319-7064

[28] Tom Guérout, Thierry Monteil, Georges Da Costa, Rodrigo Neves Calheiros, Rajkumar Buyya, Mihai Alexandru, Energy-aware simulation with DVFS, Simulation Modelling Practice and Theory 39 (2013) 76–9

[29] Wikipedia, “Cloud computing,” http://en.wikipedia.org/wiki/Cloud_computing.

[30] Zoran Pantić and Muhammad Ali Babar, “Guidelines for Building a Private Cloud Infrastructure,” IT University of Copenhagen, Technical Report No. TR-2012-153, 2012.

