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RESEARCH ARTICLE

A Study of Energy Efficiency Techniques in Cloud Computing

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Abstract- Cloud computing is an evolving paradigm that redefines the way in which Information based Technology services are being offered. Cloud Computing has created a new era in the IT industry, offering businesses and individuals technical and economical benefits, such as utilising computing resources through virtualisation and user paying only for what it uses. In cloud-based computing, the applications run on servers in the data center. These data centers contributing to high operational costs by consume huge amounts of energy and that leads to carbon footprints in the environment. So there is focus on energy consumption in data centers in cloud computing. In our study we discuss various energy efficiency techniques in cloud computing i.e DVFS, VM Consolidation, Resource throttling and DCD. A theoretical comparative study of all these energy efficiency approaches in cloud computing is done and this study shows that all these approaches are used with the goal to reduce the energy consumption and maximization of performance in the cloud computing.

Keywords— Cloud Computing, Virtualisation, Virtual Machine, Work load, Energy Efficiency, Energy Efficiency Approaches

I. INTRODUCTION

Cloud Computing has emerged as one of the most important new computing strategies in the enterprise. A combination of new technologies and processes has led to a revolution in the way that computing is developed and delivered to end users. The following definition of cloud computing has been developed by the U.S. National Institute of Standards and Technology (NIST):Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models [17]. Service delivery in cloud computing comprises three different service models, namely Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS). SaaS provides complete applications to a cloud's end user. It provides the capability to the consumer to use the applications running on a cloud infrastructure that are accessible from various client devices through a client interface such as a web browser [6]. PaaS can be defined as a computing platform that allows the creation of web applications quickly and easily without the complexity of buying and maintaining the software and infrastructure underneath it [28]. IaaS is a way of delivering cloud computing infrastructure rather than purchasing servers, software, data center space or network equipment, clients instead buys those resources as a fully outsourced service on demand. Cloud services are typically made available via four primary cloud deployment models. Private cloud, community cloud, public cloud and hybrid cloud. These models have been recommended by the National Institute of Standards and Technology (NIST). Private cloud infrastructure operates solely for a single organization, specific cloud services are dedicated to particular organization. Private clouds enforce their own data security standards and control. Community deployment model, in this model cloud infrastructure is shared by several organizations with the same policy and requirements [1]. Public cloud deployment model provides services such as applications and storage to a large group of users, over shared resources, available to the general public over the Internet. This model provides the highest degree of cost savings while requiring the least amount of overhead [23]. Hybrid cloud model comprises of two or more clouds (private, community, or public) with a mix of both internally and externally hosted services. This deployment model helps businesses to take advantage of secured applications and data hosting on a private cloud, while still enjoying cost benefits by keeping shared data and applications on the public cloud.

Virtualisation is a vital technology of Cloud Computing which offers two important features abstraction and encapsulation [9]. Virtualization divides a single physical server into multiple logical servers and each logical server can run an operating system and applications independently. Poor server utilization is one of the biggest sources of waste in most data centers. Virtualisation is mostly used in Cloud Computing platforms as means to optimise resource usage [7]. Through virtualisation, the number of hardware resources used in Clouds can be reduced to minimise the capital cost as well as the cost of power consumption and cooling systems [11]. Virtulazing the servers can increase overall utilization from around 10 percent (typical of dedicated servers to between 20 and 30 percent and over 50 percent with more dynamic management system. Successful consolidation and virtualization initiatives can also reclaim a considerable amount of rack space and stranded power [30]. Virtualisation technology is used widely in Cloud Computing data centres for better resource utilization, lowering costs, easier management of servers, server consolidation, and live migration of virtual machines [27].

II. ENERGY EFFICIENCY TECHNIQUES IN CLOUD COMPUTING

Energy efficiency has emerged as one of the most important design requirements for modern computing systems. Cloud computing has resulted in the establishment of large-scale data centres around the world. Data centres continue to consume enormous amounts of electrical power, contributing to high operational costs and carbon footprints to the environment.

Various energy efficiency techniques have been tried out in the data centres under experimental conditions. The practical application of these methods is still under study. These techniques are as follow:

Dynamic Voltage and Frequency Scaling (DVFS)**-** Dynamically change the voltage and frequency of the CPU of a host according to the work load and then alters the CPU power consumption accordingly, which would then change the performance level as well [13]. DVFS enables processor to run at different combination of frequency with voltage to reduce the power consumption of the processor. This technique observes the energy usage E of a task running with a certain frequency f that can be expressed with the following equation $E = k . v^2 . f .t$ where k is a device dependent constant, v is the voltage and t is the execution time.

VM Consolidation**-** In a cloud computing environment, every physical machine hosts a number of virtual machines upon which the applications are run [24]. Workload consolidation means better source utilization and efficient energy saving for cloud data using migration of virtual machines (VM) and re-allocation of work load**.** VM can be transferred across the hosts according to the varying needs and available resources. The VM migration method focuses on transferring VMs in such a way that the power increase is least. The most power efficient nodes are selected and the VMs are transferred across to them. Migration implies more flexible resource management as virtual machines can move from one host to another. It removes the concept of locality in virtualized environments [24].

Resource Throttling**-** is a solution for controlling how users are allowed to consume the cloud resources. Resource throttling can be done in various ways at the hardware or at the software level in-order to meet the performance requirements and minimize the energy consumption. In a cloud environment, there are several parameters which can be throttled they are Network bandwidth, storage, CPU usage and I/O operations [29].

Dynamic Component De-Activation (DCD) **-**is activation and deactivation of the components on the basis of defined rules and dynamic conditions that leading to better performance. It is a technique where in the idle severs or components could be switched off or moved to less power consuming state like sleep mode. It has been experimentally determined that an ideal server consumes about 70% of the power utilized by a fully utilized server [20].

III. LITERATURE REVIEW

Jayshri Damodar Pagare and Nitin A Koli [19] presented the introduction to cloud computing and challenges for energy-efficient management of cloud computing environments. Study focus on the cloud computing with virtualization as a way to achieve the efficiency in energy consumption and showed the significant trade-offs between performance, QoS and energy efficiency.

Arindam Banerjee et al. [2] explained the need of power consumption and energy efficiency in cloud computing model. It shows that there are few major components of cloud architecture which are responsible for high amount of power dissipation in cloud. The possible ways to meet each sector for designing an energy efficiency model has also been studied.

Rajkumar Buyya et al. [4] explained the challenges in the field of cloud computing in terms of energy and cost while meeting QoS requirements defined by the SLAs. Paper addressed the problem of enabling energy-efficient resource allocation, leading to Green Cloud computing. Explains the green cloud architectural elements and precisely focused on Energy-Efficient Management of Data center resources for cloud computing.

Chia-Ming Wu et al. [26] introduced a green energy-efficient scheduling algorithm using DVFS technique for cloud computing data centers. Property of the DVFS to enables processors to run at different combinations of frequencies with voltages to reduce the power consumption of the processor is made the key to algorithm.

Bo Li et al. [15] discussed the energy aware heuristic algorithm based on workload distributation in virtual machine with minimum number of virtual machines or nodes required for particular workload. The workload migration, workload resizes virtual machine migration are the approaches are used in algorithm.

Meisner et al. [16] had proposed a PowerNap, an energy-conservation approach where the entire system transitions rapidly between a high-performance active state and a near-zero-power idle state in response to instantaneous load. Thus the goal is to minimize power consumption by a server while it is in an idle state.

Elnozahy et al. [8] explored the problem of power-efficient resource management in a homogeneous cluster serving a single web application with SLAs (Service Level Agreements) defined in terms of response time constraints. The approach applied two power management mechanisms: switching servers on and off (Vary-On Vary-Off, VOVO) and DVFS.

Anton Beloglazov [3] studied minimization of energy consumption under performance constraints. Investigated energy-efficient dynamic VM consolidation under QoS constraints applied to virtualized data centers containing heterogeneous physical resources. Focus on IaaS cloud environments is made. In this study, the maximum amount of RAM that can be consumed by a VM is used as a constraint when placing VMs on servers; work presented in this study compares the related research in the distributed architecture of the VM management system.

Song et al. [22] studied the problem of efficient resource allocation in multi-application virtualized data centers. The objective was to improve the utilization of resources leading to the reduced energy consumption. Only the CPU and RAM utilization are taken into account in resource management decisions. Proposed scheduling at three different levels: the application-level scheduler dispatches requests across the application's VMs; the local level scheduler allocates resources to VMs running on a physical node according to their priorities; and the global-level scheduler controls the resource "flow" between the applications.

Kyong Hoon Kim et al. [12] investigated the power-aware provisioning of virtual machines for real-time services. They modelled a real-time service as a real-time virtual machine request and provisioned virtual machines of data centers using DVFS schemes. Proposed three policies for scheduling real-time VMs in a data center using DVFS to reduce energy consumption. Also proposed three real-time cloud service frameworks schemes Lowest-DVS, d-Advanced-DVS and Adaptive-DVS. Performance comparison between these three different policies was made by using Cloud Sim toolkit considering different values of the thresholds. Result showed that data centers can reduce power consumption and increase their profit using DVS schemes.

IV. NEED OF STUDY

The Cloud computing has resulted in the establishment of large-scale data centers around the world containing thousands of compute nodes. Data centers hosting cloud applications consume huge amounts of energy, in form of electrical energy that is contributing to high operational costs. Apart from the overwhelming operating costs due to high energy consumption, another rising concern is the environmental impact in terms of carbon dioxide (CO_2) emissions caused by this high energy consumption. According to Institute of Standards and Technology (NIST) – "the major objective of cloud computing is to maximize the shared resources and at the same time the disadvantage is its high infrastructure cost and unnecessary power consumption" [17]. Thus there is a need of techniques that solves the problem of high energy consumption in cloud computing, so currently main focus is on energy consumption in cloud data centers.

V. OBJECTIVE OF STUDY

I) To explore the different existing energy efficiency techniques in cloud computing.

II) To perform a comparative study of different energy efficiency approaches in cloud computing.

VI. RESEARCH METHODOLOGY

In order to meet the objective theoretical approach has been used. The theoretical approach concentrates on describing cloud computing, virtualization, energy efficiency and its various techniques. The theoretical approach is based on review of secondary data acquired from literature survey, articles, books, research paper and internet.

VII. ANALYSIS

A combination of new technologies and processes has led to a revolution in the way the computing is developed and delivered to end users. A large number of cloud computing systems emit a considerable amount of carbon dioxide and waste a tremendous amount of energy. Various approaches and their techniques are existing which effectively contributes to the energy efficiency in cloud computing.

Table I: Study of Energy Efficiency Approaches in Cloud Computing

Author	Resource	Technique	Goal	Proposed Approach
Ripal Nathuji and Karsten Schwan [18]	CPU	DVFS VM consolidation Server power switching Soft scaling Throttling	Minimize energy consumption, Satisfy performance requirements	Virtual Power Management
Akshat Verma et al. [25]	CPU	DVFS VM consolidation Server power switching	Min power under performance constraints	pMapper
Ramya Raghavendra et al. [21].	CPU	DVFS VM consolidation Server power switching	Minimize power consumption, Minimize performance loss, while meeting power budget	Coordinated architecture, uncoordinated solution with five individual power management solutions
Kyong Hoon Kim et al. [12]	CPU	Leveraging heterogeneity, DVFS	Min. energy under performance constraints	Lowest-DVS , Advanced-DVS, Adaptive-DVS
Michael Cardosa et al. [5]	CPU	DFVS, Soft scaling	Minimize power consumption under performance constraints	Power Expand Min Max Algorithm
Daniel Gmach et al.[10]	CPU, Memory	VM consolidation, Server power switching	Maximize resource utilization, Satisfy performance requirements	New quality of service metrics and a case study

Dara Kusic et al. [14]	CPU	VM consolidation, Server power switching	Min power under performance constraints	Resource provisioning framework
Baiyi Song et al. [22]	CPU, RAM	Resource throttling	Min. energy under performance constraints	Application-level scheduler, local level scheduler, global level scheduler
Mark Stillwell et al. [24]	CPU	VM consolidation, resource throttling	Min. energy under performance constraints	Heuristic algorithms

Table I shows various authors, resource utilized (i.e CPU, memory, network etc,) study conducted by authors with particular goals of minimization of energy consumption or satisfying performance constraints or meeting power budget or maximize resource utilization, techniques applied to gain maximum energy efficiency and various proposed approaches given by authors for energy efficiency in cloud computing are shown. From table I we found that CPU is the main resource in focus for the purpose of energy efficiency in various proposed approaches. From the above table we analysed that various energy efficiency techniques are used for energy efficiency in cloud computing and instead of using any single technique various authors used the combination of DVFS, VM Consolidation, Resource throttling and DCD techniques.

VIII. CONCLUSION

In this paper the need of power consumption and energy efficiency in cloud computing model have been shown. It has been shown that there are few major components of cloud architecture which are responsible for energy saving. CPU as compare to the other resources like memory, hardware (servers/nodes) leads to more energy efficiency in cloud computing. Secondly we conclude that individual energy efficiency techniques are combined together to obtain maximum efficiency in term of energy and at last minimization of energy and maximization of the resource utility are the main objective of the various approaches in cloud computing. There are many possible directions of future work. Techniques proposed by different authors could be compared experimentally and tested, to find the one that is more efficient in saving energy in cloud computing. Energy efficient approach in cloud computing considering several factors like Quality of Service, network topology, server scheduling etc has become a challenging problem. Developing an algorithm that provide the maximum energy efficiency without compromising the Quality of Service in cloud computing.

REFERENCES

[1] Atrey, Ankita, and Nikita Jain. "A Study on Green Cloud Computing." *International Journal of Grid and Distributed Computing Vol. 6, No. 6 (2013).*

[2] Banerjee, Arindam, Prateek Agrawal and N. Ch. S. N. Iyengar "Energy Efficiency Model for Cloud Computing" *International Journal of Energy, Information and Communications Vol.4, Issue 6 (2013), pp.29-42*

[3] Beloglazov, Anton "Energy-Efficient Management of Virtual Machines in Data Centers for Cloud Computing" *Department of Computing and Information Systems The University Of Melbourne*.

[4] Buyya, Rajkumar, Anton Beloglazov, and Jemal Abawajy. "Energy-efficient management of data center resources for cloud computing: A vision, architectural elements, and open challenges." *arXiv preprint arXiv: 1006.0308*(2010).

[5] Cardosa, Michael, Madhukar R. Korupolu, and Aameek Singh. "Shares and utilities based power consolidation in virtualized server environments." *Integrated Network Management, 2009. IM'09. IFIP/IEEE International Symposium on*. IEEE, 2009.

[6] Deore, Shailesh, A. N. Patil, and Ruchira Bhargava. "Energy-Efficient Scheduling Scheme for Virtual Machines in Cloud Computing." *International journal of computer application* 56.10 (2012).
[7] Duran-Limon, H. et al . "Using Lightweight Virtual Machines to Run High Performance Computing Applications: The Case of Weather Research and Forecasting Model*" Fourth IEEE International Conference on Utility and Cloud Computing*(2011).
[8] Elnozahy, EN Mootaz, Michael Kistler, and Ramakrishnan Rajamony. "Energy-efficient server clusters." *Power-Aware Computer Systems*. Springer Berlin Heidelberg, 2003. 179-197
[9] Foster, Ian, et al. "Cloud computing and grid computing 360-degree compared."*Grid Computing Environments Workshop, 2008. GCE'08*. Ieee, 2008.
[10] Gmach, Daniel, et al. "Resource pool management: Reactive versus proactive or let's be friends." *Computer Networks* 53.17 (2009): 2905-2922.
[11] Hardy, James, et al. "Assessment and Evaluation of Internet-based Virtual Computing Infrastructure." *Object/Component/Service-Oriented Real-Time Distributed Computing (ISORC), 2012 IEEE 15th International Symposium on*. IEEE, 2012.
[12] Kim, Kyong Hoon, Anton Beloglazov, and Rajkumar Buyya. "Power-aware provisioning of cloud resources for real-time services." *Proceedings of the 7th International Workshop on Middleware for Grids, Clouds and e-Science*. ACM, 2009.
[13] Kliazovich, Dzmitry, Pascal Bouvry and Samee Ullah Khan. "DENS: data center energy-efficient network-aware scheduling." *Cluster computing* 16.1 (2013): 65-75.
[14] Kusic, Dara, et al. "Power and performance management of virtualized computing environments via lookahead control." *Cluster computing* 12.1 (2009): 1-15.
[15] Li, Bo, et al. "Enacloud: An energy-saving application live placement approach for cloud computing environments." *Cloud Computing, 2009. CLOUD'09. IEEE International Conference on*. IEEE, 2009.
[16] Meisner, David, Brian T. Gold, and Thomas F. Wenisch. "PowerNap: eliminating server idle power." *ACM SIGARCH Computer Architecture News* 37.1 (2009): 205-216. [16] Li, Jiandun, Junjie Peng, and Wu Zhang. "A scheduling algorithm for private clouds." *Journal of Convergence Information Technology* 6.7 (2011): 1-9.
[17] Mell, Peter, and Tim Grance. "The NIST definition of cloud computing." (2011). [Internet], NationalInstitute of Standards and Technology, September, p.1-3. Available from:<http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf> [Accessed 8th June 2012]
[18] Nathuji, Ripal, and Karsten Schwan. "Virtualpower: coordinated power management in virtualized enterprise systems." *ACM SIGOPS Operating Systems Review*. Vol. 41. No. 6. ACM, 2007.
[19] Pagare, Damodar ,Jayshri, and Dr.Nitin A Koli "Energy- Efficient Cloud Computing: A Vision, Introduction, Efficient Cloud Computing: A Vision, Introduction, and Open Challenges*" IJCSN International Journal of Computer Science and Network, Vol 2, Issue 2, April 2013.*
[20] Patterson, David A. "The data center is the computer." *Communications of the ACM* 51.1 (2008): 105-105.
[21] Raghavendra, Ramya, et al. "No power struggles: Coordinated multi-level power management for the data center." *ACM SIGARCH Computer Architecture News*. Vol. 36. No. 1. ACM, 2008.
[22] Song, Baiyi, Carsten Ernemann, and Ramin Yahyapour. "Parallel computer workload modeling with markov chains." *Job Scheduling Strategies for Parallel Processing*. Springer Berlin Heidelberg, 2005.
[23] Srikantaiah, Shekhar, Aman Kansal, and Feng Zhao. "Energy aware consolidation for cloud computing." *Proceedings of the 2008 conference on Power aware computing and systems*. Vol. 10. 2008.
[24] Stillwell, Mark, et al. "Resource allocation using virtual clusters." *Cluster Computing and the Grid, 2009. CCGRID'09. 9th IEEE/ACM International Symposium on*. IEEE, 2009.
[25] Verma, Akshat, Puneet Ahuja, and Anindya Neogi. "pMapper: power and migration cost aware application placement in virtualized systems." *Middleware 2008*. Springer Berlin Heidelberg, 2008. 243-264.
[26]Wu, Chia-Ming, Ruay-Shiung Chang, and Hsin-Yu Chan. "A green energy-efficient scheduling algorithm using the DVFS technique for cloud datacenters."*Future Generation Computer Systems* 37 (2014): 141-147.
[27] Ye, Kejiang, et al. "Virtual machine based energy-efficient data center architecture for cloud computing: a performance perspective." *Proceedings of the 2010 IEEE/ACM Int'l Conference on Green Computing and Communications & Int'l Conference on Cyber, Physical and Social Computing*. IEEE Computer Society, 2010.
[28] http://en.wikipedia.org/wiki/Platform_as_a_service
[29]http://wso2.com/library/articles/2011/08/throttling-cloud-computing-environment/
[30]http://www.itbusinessedge.com/slideshows/ten-tips-for-improving-data-center-energy- efficiency03.html

