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Energy-efficient Virtual Machine Placement Algorithm using Holding Time

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Abstract: **Cloud computing is a parallel and distributed network of virtualized computers that are dynamically provided and scaled according to varying needs and as a unified resource Cloud computing infrastructure comprises of hardware and software domains. Cloud computing is popular technology, but there are many challenges associated with it. With an increase in awareness of environmental concerns, energy-efficiency has become a challenge driving attention in Cloud computing also. In the software domain there are various ways by which energy-efficiency can be achieved, which are- Virtual Machine (VM) placement, VM scheduling, VM reconfiguration, VM migration, VM consolidation. Since virtualization is the backbone of cloud computing so these ways are good research areas. These methods are collectively known by the term Cloud Management System (CMS).Many VM placement algorithms exist which are energy-efficient but a few consider geo-distributed datacenters. In this work the problem of VM placement is considered in geo-distributed datacenters. A novel Holding Time based VM placement Algorithm (HTVMA) is proposed which is based on holding times of VMs. The tool used for simulation is CloudSim Plus and the algorithm is compared with Best-Fit and First-Fit algorithms. The proposed algorithm is more energy-efficient than these both.**

Keywords — Cloud computing, Cloud Management System (CMS), Energy-efficiency, geo-distributed datacenters, holding time, Holding Time based VM placement Algorithm (HTVMA), Virtual Machine, VM placement.

I. INTRODUCTION

Cloud is a nebulous interconnection of computers and servers accessed by the internet [1]. Cloud computing is a paradigm focused to deliver computing as a utility [2]. Cloud data centers consume huge amount of energy and leave a high carbon footprint on the environment [3]. World Energy Council describes about energy efficiency as decrease of energy employed for a given purpose [24]. To achieve energy efficiency in cloud computing there is a need to minimize energy loss and energy waste.

Energy efficiency can be achieved at the server level by consolidation and virtualization, at data center level by migration, power on/off severs, prediction based-algorithms, green SLA-aware techniques, and at geo-distributed data centers by using Virtual Machine (VM) placement and migration, workload placement and distribution, economy-based cost aware techniques, data center characteristics like location and configuration aware techniques[3].

There are four approaches to mitigate energy savings in cloud computing, which are either through reconfiguration, placement, scheduling, or migration and consolidation of VMs. A VM is a software implementation of a machine which executes programs just like physical machine. Virtualization forms the foundation of cloud computing, as it provides the capability of pooling computing resources from clusters of servers and dynamically assigning or reassigning virtual resources to applications on-demand, including physical servers, routers, switches, power and cooling systems [5]. Since virtualization is a core technology of cloud computing, the problem of VM placement is an important topic for improving power efficiency and resource utilization in cloud infrastructures [7].

VM reconfiguration is done to reduce stress on the system and energy consumption. Physical machines can be adjusted to load or self-adapting VMs to resource demand can be developed or middleware can adapt resources' demand to need. VM scheduling techniques include scheduling algorithms which are used for scheduling VM requests to physical machine of particular data center over time as per requirements fulfilled with the requested resources. Scheduling algorithms can be static (e.g. first come first serve), dynamic (e.g. genetic algorithms), greedy algorithms (e.g. round robin algorithms) or rank based [6]. VM

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migration and VM consolidation state that VMs can be moved either offline or online between physical machines so as to consolidate load on fewer machines and powering off the unused machines [4]. The process of selecting the most suitable host for the VM while deploying a VM on a host is known as VM placement and a VM placement algorithm aims at determining the most optimal VM to Physical Machine (PM) mapping whether it is an initial VM placement or a VM placement after migration for re-optimization [8].

The VM placement problem is the problem of finding a suitable placement for VMs driven by different goals. Mathematically, the VM placement problem can be stated as:

Let a physical host list is given H_{list}= {H1, H2… Hn}

And Virtual Machine Monitor (VMM) has received VM requests and stored in a queue

V_{queue}= {V1, V2, V3…Vn}

Then, the mapping from the H_{list} to V_{queue} w.r.t goal of VM placement is known as VM Placement Problem (VMPP). In this paper, the goal is energy-efficiency and a novel VM placement algorithm is proposed. The main contributions of this paper are: an energy- efficient VM placement algorithm based on VM holding times, which takes into account geo-distributed datacenters; a self-generated dataset for a comprehensive comparison of the novel algorithm and different VM placement algorithms with respect to power consumption; a set of graphs depicting pictographically the results of comparison.

The remainder of the paper is structured as follows. Section II gives literature review. Section III describes the research methodology. In section IV the proposed VM placement algorithm is stated. Section V depicts the results. Section VI concludes the study and also gives the future scope.

II. LITERATURE REVIEW

Yongqiang Gao et al. [7] presented a multi-objective ant colony system algorithm VMPACS for VM placement with a goal to simultaneously minimize total resource wastage and power consumption. Atefeh Khosravi et al. [10] proposed a VM placement algorithm, Energy and Carbon-Efficient (ECE) cloud architecture which benefits from distributed cloud data centers with different carbon footprint rates, PUE value, and different physical servers' proportional power. Nguyen Quang-Hung et al. [11] presented a Genetic Algorithm for Power-Aware (GAPA) VM allocation in a private cloud. Dapeng Dong and John Herbert [12] gave energy efficient VM Placement supported by data analytic service, i.e. the R decision support system rDSS. H. M. Ali and Daniel C. Lee [13] presented a Biogeography-Based Optimization (BBO) algorithm for energy efficient VM placement. Christina Terese Joseph et al. [14] presented a Family Genetic Approach (FGA) for VM allocation. T. Thiruvenkadam and P. Kamalakkannan [15] gave an energy efficient multi-dimensional host load aware algorithm for VM placement and optimization in a cloud environment.

H. M. Ali and Daniel C. Lee [17] presented Information-based Enhanced Fire-Works Algorithm (IEFWA) and a hybrid IEFWA/BBO algorithm. Atefeh Khosravi et al. [18] presented a dynamic VM Placement method for minimizing energy and carbon cost in geographically distributed Cloud data centers. Esha Barlaskar et al. [19] presented an energy-efficient VM placement using an enhanced firefly algorithm. Xiaoning Zhang et al [20] presented a performance-aware energy-efficient Virtual Machine placement in the cloud data center. Riaz Ali et al. [21] proposed a VMR: Virtual Machine Replacement Algorithm for Energy-Awareness in Cloud Data Centers without reducing the Quality of Service (QoS) for user's deadline requirements in cloud data centers. Qian Zhang et al. [22] presented an energy-aware VM placement with periodical dynamic demands in cloud data centers. Meera Vasudevan et al. [23] proposed a Repairing Genetic Algorithm (RGA) for energy-efficient application assignment in profile-based data center management with a 3-level architecture. Toni Mastelic et al. [4] presented survey on energy efficiency in cloud computing. Ankita Choudhary et al. [16] have done a critical analysis of dynamic energy efficient virtual machine placement techniques. Wissal Attaoui and Essaid Sabir [9] presented a literature review on multi-criteria virtual machine placement in cloud computing environments.

Most of the VM placement algorithms already existing do not take energy-efficiency into account. Some have energy-efficiency as the goal, but they do not take into account distributed data centers and their green energy availability into account. None of the algorithm takes into account both number of processing elements and holding times. The proposed algorithm takes into account energy-efficiency in case of distributed data centers by taking into account the green energy available for the data centers. Also, it is based on both holding time and the number of processing elements required by the VMs.

III. RESEARCH METHODOLOGY

Research methodology is a way to systematically solve the research problem. It describes the type of research method(s) used, dataset used and the tool used for simulation.

The study was based on systematic observation of the secondary resources. Firstly, various websites, research papers, journals, surveys were viewed and studied related to virtual machine placement in cloud computing for which a qualitative research methodology was used.

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Secondly, a new algorithm was proposed which was implemented using simulation tool. To justify the new research findings a quantitative research methodology was used. So, the research work used both qualitative and quantitative approaches to frame the research findings.

The dataset used was self-generated and the simulation tool used was CloudSim Plus. CloudSim Plus is a fork of CloudSim 3. CloudSim Plus is re-engineered specially to make it devoid of duplicate code. Also it is an open-source simulator available online.

IV. PROPOSED ALGORITHM

The proposed algorithm considers VM holding time at the time of VM placement and selects the destination data center and server. If a server hosts VMs with different holding times, then VMs termination in different times could lead to resource wastage, and consequently high energy consumption and carbon footprint.

Taking an example, let there be two hosts and four VMs with holding times as x-20, x+10, x-10, x and IDs as 1, 2, 3 and 4 respectively. Let the number of processing elements available of the hosts and the number of processing elements required by VMs be such that each host can accommodate only two VMs. Now if VM1 and VM2 are allocated to host1 then VM1 will finish earlier and VM2 will take 30 more seconds, so the host will consume energy till that time but if VMs are sorted first based on their holding times then such extra energy consumption can be avoided by placing the VMs in order of holding times. Also the algorithm considers data centers with maximum available renewable energy (green energy). Therefore, studying the impact of VM holding times and the hosted data center and server on the total energy and carbon footprint could help the Cloud Service Provider (CSP) makes better decision at the time of VM allocation. The steps of the algorithm are as given below:

Algorithm: Holding time based VM Allocation algorithm (HTVMA)

Input: a list of datacenters and their green energy, hostlist, vmlist with their holding times.

Output: destination map of vms and total power value of all hosts.

1. *Input*: a list of *datacenters* and their green energy, *hostlist*, *vmlist* with their holding times.
2. for each *datacenter* from datacenters list do
3. Find max (green energy)
4. Selected *datacenter* = *datacenter* with Max (green energy)
5. Sort the *vmlist* in ascending order of holding times.
6. for each *vm* in sorted *vmlist* do
7. Select *host* from *hostlist* with least pes suitable for *vm*
8. Allocate the selected host to this *vm*
9. Destination for *vm*= (selected *datacenter*, selected *host*)
10. for each *host* in *hostlist* do
11. Calculate *host* utilization at small time intervals.
12. Calculate power consumed by *host* based on *host* utilization at each time interval.
13. Calculate total power consumed by *host* by adding the values of step 12.
14. for each *host* in selected *datacenter* do
15. Calculate total power value by adding values from step 13.
16. *Output*: Return destination map of *vms* and total power value from step 15.

V. RESULTS

The proposed algorithm was compared with both best-fit algorithm and first-fit algorithm. The first-fit algorithm finds the first host having suitable resources to place a given VM. The best-fit algorithm chooses, as the host for a VM, that one with the most processing elements in use. The energy-consumption of the proposed algorithm was lesser than both of them as shown in the graphs. The comparison is done by varying the number of virtual machines for the same set of cloudlets and evaluating energy consumption of hosts for different number of virtual machines. The results are shown in Figure 1and Figure 2 with respect to first-fit and best-fit respectively.

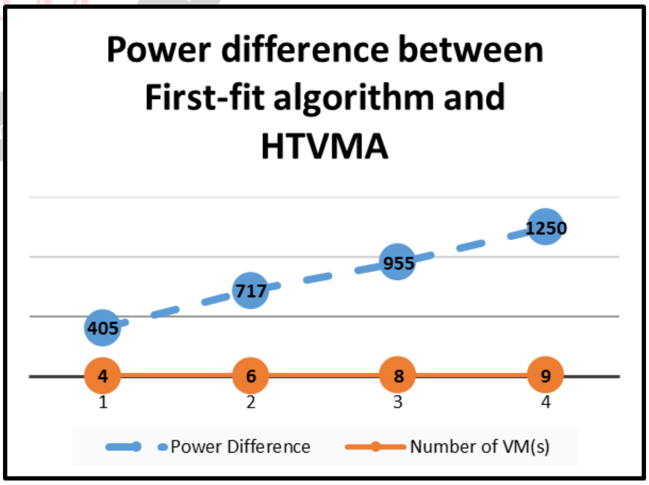

Figure 1: Comparison of power values for HTVMA and first-fit algorithm.

Figure 1 shows the power difference values by varying the number of VMs. The power difference value is calculated by noting down the total power consumption by applying the first-fit algorithm and then subtracting it from total power consumed by hosts after applying the proposed algorithm HTVMA. It shows that the power difference is

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405 Watt/seconds when the number of VMs are 4 and so on.

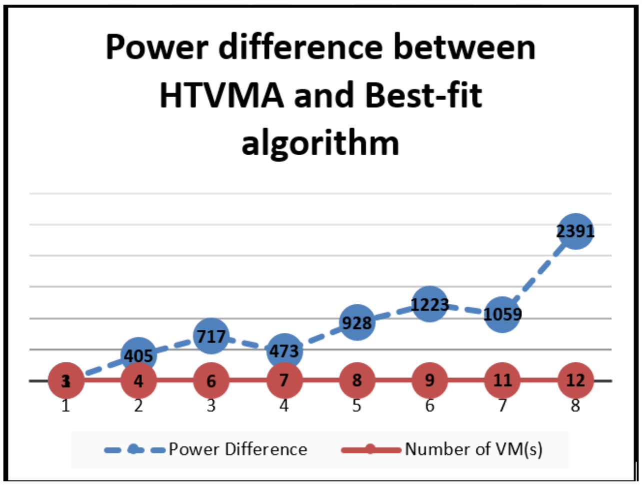

Figure 2: Comparison of power values for HTVMA and best-fit algorithm.

Similarly, Figure 2 shows the power difference values by varying the number of VMs in case of comparison with best-fit algorithm. Again, the power difference value is calculated by noting down the total power consumption by applying the best-fit algorithm and then subtracting it from total power consumed by hosts after applying the algorithm HTVMA. It shows that the power difference is 405 Watt/seconds when the number of VMs are 4 and so on for different number of VMs.

VI. CONCLUSION AND FUTURE SCOPE

It is evident from the graphs given in Figures 1 and 2 that the proposed algorithm i.e. HTVMA is better than both best-fit and first-fit algorithms in terms of energy consumption. So the algorithm gives the desired results. Also the algorithm first selects a relevant data center with maximum green energy production per unit time so it applies to distributed data centers.

The dataset used was self-generated so for further improvement the algorithm can be tested for some real-time dataset. Also the VM list was taken beforehand i.e. the algorithm is not dynamic so this algorithm can be further improved to incorporate dynamic VM arrival. This algorithm can be further integrated with energy-efficient techniques of cloudlets' placement on VMs to achieve better results.

REFERENCES

[1] Miller, Michael. Cloud computing: Web-based applications that change the way you work and collaborate online. Que publishing, 2008.

[2] Buyya, Rajkumar, Chee Shin Yeo, Srikumar Venugopal, James Broberg, and Ivona Brandic. "Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility." Future Generation computer systems 25.6 (2009): 599-616.

[3] Khosravi, Atefeh, and Rajkumar Buyya. "Energy and Carbon Footprint-Aware Management of Geo-Distributed Cloud Data Centers." Advancing cloud database systems and capacity planning with dynamic applications (2017): 27.

[4] Mastelic, Toni, Ariel Oleksiak, Holger Claussen, Ivona Brandic, Jean-Marc Pierson, and Athanasios V. Vasilakos. "Cloud computing: Survey on energy efficiency." Acm computing surveys (csur) 47.2 (2015): 33.

[5] Zhang, Qi, Lu Cheng, and Raouf Boutaba. "Cloud computing: state-of-the-art and research challenges." Journal of internet services and applications 1.1 (2010): 7-18.

[6] Prajapati, Karan D., Pushpak Raval, Miren Karamta, and M. B. Potdar. "Comparison of virtual machine scheduling algorithms in cloud computing." International Journal of Computer Applications 83.15 (2013).

[7] Gao, Yongqiang, Haibing Guan, Zhengwei Qi, Yang Hou, and Liang Liu. "A multi-objective ant colony system algorithm for virtual machine placement in cloud computing." Journal of Computer and System Sciences 79.8 (2013): 1230-1242.

[8] Usmani, Zoha, and Shailendra Singh. "A survey of virtual machine placement techniques in a cloud data center." Procedia Computer Science 78 (2016): 491-498.

[9] Attaoui, Wissal, and Essaid Sabir. "Multi-Criteria Virtual Machine Placement in Cloud Computing Environments: A literature Review." arXiv preprint arXiv: 1802.05113 (2018).

[10] Khosravi, Atefeh, Saurabh Kumar Garg, and Rajkumar Buyya. "Energy and carbon-efficient placement of virtual machines in distributed cloud data centers." European Conference on Parallel Processing. Springer, Berlin, Heidelberg, 2013.

[11] Quang-Hung, Nguyen, Pham Dac Nien, Nguyen Hoai Nam, Nguyen Huynh Tuong, and Nam Thoai. "A genetic algorithm for power-aware virtual machine allocation in private cloud." Information and Communication Technology-EurAsia Conference. Springer, Berlin, Heidelberg, 2013.

[12] Dong, Dapeng, and John Herbert. "Energy efficient vm placement supported by data analytic service." Cluster,

 DOI : 10.18231/2454-9150.2018.0907

Cloud and Grid Computing (CCGrid), 2013 13th IEEE/ACM International Symposium on. IEEE, 2013.

[13] Ali, Hafiz Munsub, and Daniel C. Lee. "A biogeography-based optimization algorithm for energy efficient virtual machine placement." Swarm Intelligence (SIS), 2014 IEEE Symposium on. IEEE, 2014.

[14] Joseph, Christina Terese, K. Chandrasekaran, and Robin Cyriac. "A novel family genetic approach for virtual machine allocation." Procedia Computer Science 46 (2015): 558-565.

[15] Thiruvenkadam, T., and P. Kamalakkannan. "Energy efficient multi-dimensional host load aware algorithm for virtual machine placement and optimization in cloud environment." Indian Journal of Science and Technology 8.17 (2015).

[16] Choudhary, Ankita, Shilpa Rana, and K. J. Matahai. "A critical analysis of energy efficient virtual machine placement techniques and its optimization in a cloud computing environment." Procedia Computer Science 78 (2016): 132-138.

[17] Ali, Hafiz Munsub, and Daniel C. Lee. "Optimizing the energy efficient VM placement by IEFWA and hybrid IEFWA/BBO algorithms." Performance Evaluation of Computer and Telecommunication Systems (SPECTS), 2016 International Symposium on. IEEE, 2016.

[18] Khosravi, Atefeh, Lachlan LH Andrew, and Rajkumar Buyya. "Dynamic vm placement method for minimizing energy and carbon cost in geographically distributed cloud data centers." IEEE Transactions on Sustainable Computing 2.2 (2017): 183-196.

[19] Barlaskar, Esha, Yumnam Jayanta Singh, and Biju Issac. "Energy-efficient virtual machine placement using enhanced firefly algorithm." Multiagent and Grid Systems 12.3 (2016): 167-198.

[20] Zhang, Xiaoning, Yangming Zhao, Shuai Guo, and Yichao Li. "Performance-aware Energy-efficient Virtual Machine Placement in Cloud data center." Communications (ICC), 2017 IEEE International Conference on. IEEE, 2017.

[21] Ali, Riaz, Yao Shen, Xiangwei Huang, Jingyu Zhang, and Ahmad Ali. "VMR: Virtual Machine Replacement Algorithm for QoS and Energy-Awareness in Cloud Data Centers." Computational Science and Engineering (CSE) and Embedded and Ubiquitous Computing (EUC), 2017 IEEE International Conference on. Vol. 2. IEEE, 2017.

[22] Zhang, Qian, Hua Wang, Fangjin Zhu, Shanwen Yi, Kang Feng, and Linbo Zhai. "Energy-Aware VM Placement with Periodical Dynamic Demands in Cloud Datacenters." High Performance Computing and Communications; IEEE 15th International Conference on Smart City; IEEE 3rd International Conference on Data Science and Systems (HPCC/SmartCity/DSS), 2017 IEEE 19th International Conference on. IEEE, 2017.

[23] Vasudevan, Meera, Yu-Chu Tian, Maolin Tang, Erhan Kozan, and Xueying Zhang. "Energy-efficient Application Assignment in Profile-based Data Center Management Through a Repairing Genetic Algorithm." Applied Soft Computing (2018).

[24] Moisan, Francois, and Didier Bosseboeuf. "Energy Efficiency: A Recipe for Success." World Energy Council, London, UK, Tech. Rep (2010).

 DOI : 10.18231/2454-9150.2018.0907