IMPLEMENTATION OF LOCUST INSPIRED SCHEDULING ALGORITHM WITH HUGE NUMBER OF SERVERS FOR ENERGY EFFICIENCY IN A CLOUD DATACENTER

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Computer Science

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In recent times, with the rapid development of cloud computing has affected to energy consumption which gives negative impact towards the environment through production of carbon dioxide. A decentralized Locust-inspired scheduling algorithm (LACE) is one way to minimize the level of energy consumption in cloud datacenters. LACE algorithm is used to schedule and optimize Virtual Machine (VMs) allocation across the servers according to behaviour obtained from locust nature. LACE migrate the VM from under loaded server to other overloaded server in order to decrease the total number of running server. The running servers can be shut down and save the energy used. In the benchmark paper, the result of implementation of LACE algorithm in 400, 600, 800 and 1000 servers were plotted at different graphs. No comparison between the results has been made into one graph. Moreover, the implementation of LACE algorithm in datacenter consisting of 400, 600, 800 and 1000 servers only were created. It does not consider the LACE algorithm implemented in huge number of server in one Cloud datacenter. So, the objective for this paper is to evaluate the results in the benchmark paper and to evaluate the implementation of LACE algorithm in a huge number of servers within

one cloud datacenter. LACE algorithm is executed in 1000, 2000, 3000 and 4000 servers to see the performance in Cloud datacenter. Cloudsim is used as Discrete Event Simulation tool and Java as coding language to evaluate LACE algorithm. The performance metrics are measured is energy consumption. The result show that if the request is high, the amount of energy consumption decrease because more number of migrations occur and more running servers used can be shut down. At low request, there is no any significance effect the level of energy consumption between the distinct number of servers since less number of migration occur.

Abstrak tesis dikemukakan kepada senat University Putra Malaysia sebagai memenuhi keperluan untuk ijazah untuk Master Sains Komputer

PELAKSANAAN PENJADUALAN ALGORITMA BERINSPIRASI BELALANG DENGAN JUMLAH BILANGAN PELAYAN YANG BESAR UNTUK KECEKAPAN TENAGA DALAM PUSAT DATA AWAN

Oleh

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Pada kebelakangan ini, dengan perkembangan pesat pengkomputeran awan telah memberi kesan kepada penggunaan tenaga yang memberikan impak negatif terhadap alam sekitar melalui pengeluaran karbon dioksida. Algoritma penjadualan terinspirasi belalang (LACE) adalah salah satu cara untuk meminimumkan tahap penggunaan tenaga di datacenters awan. Algoritma LACE digunakan untuk menjadualkan dan mengoptimumkan Peruntukan Mesin Maya (VM) di seluruh pelayan mengikut tingkah laku yang diperolehi daripada sifat belalang. LACE memindahkan VM dari bawah pelayan yang dimuat ke pelayan yang terlalu banyak untuk mengurangkan jumlah pelayan yang sedang berjalan. Pelayan yang sedang berjalan boleh ditutup dan menyimpan tenaga yang digunakan. Dalam kertas penanda aras, hasil pelaksanaan algoritma LACE dalam 400, 600, 800 dan 1000 pelayan telah diplotkan pada grafik yang berbeza. Tiada perbandingan antara hasil yang dibuat menjadi satu graf. Selain itu, pelaksanaan algoritma LACE di datacenter yang terdiri daripada 400, 600, 800 dan 1000 server hanya dibuat. Ia tidak menganggap algoritma LACE dilaksanakan dalam jumlah besar pelayan dalam satu

pusat data Awan. Oleh itu, matlamat untuk kertas ini adalah untuk menilai hasil dalam kertas penanda aras dan untuk menilai pelaksanaan algoritma LACE dalam sebilangan besar pelayan dalam satu pusat data awan. Algoritma LACE dijalankan pada 1000, 2000, 3000 dan 4000 pelayan untuk melihat prestasi di pusat data Awan. Cloudsim digunakan sebagai alat Simulasi Acara Diskret dan Java sebagai bahasa pengekodan untuk menilai algoritma LACE. Metrik prestasi diukur adalah penggunaan tenaga. Hasilnya menunjukkan bahawa jika permintaan itu tinggi, jumlah penggunaan tenaga berkurangan kerana lebih banyak jumlah migrasi berlaku dan lebih banyak pelayan berjalan yang digunakan boleh ditutup. Atas permintaan yang rendah, tidak terdapat sebarang kesan penting terhadap tahap penggunaan tenaga di antara bilangan pelayan yang berbeza kerana bilangan penghijrahan yang kurang.

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APPROVAL SHEETS

This thesis was submitted to the Faculty of Computer Science and Information Technology of Universiti Putra Malaysia and has been accepted as partial fulfillment of the requirement for the award of degree of Master of Computer Science.
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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other any other institutions.

NUR HUWAINA AZHAR

Date :

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LIST OF ABBREVIATION

LACE	Locust-inspired scheduling Algorithm to reduce Cloud Computing Consumed Energy
VM	Virtual Machine
DVFS	Dynamic Voltage Frequency Scaling
ESWCT	Energy-aware Scheduling using the Workload-aware Consolidation Technique
DENS	Datacenter Energy-efficient Network-aware Scheduling
ACO	Ant Colony Optimization
LLS	Least Loaded Server
MIPS	Million Instruction Per Second
FIFO	First In First Out
CSR	Centralized System Registry
CT	Consolidation Threshold
PS	Powerful Server
WS	Weak Server
PCT	Processing Capabilities Threshold
PC	Processing Capability
HEAVY	Heavily Loaded Server
PU	Processor Utilization
LIGHT	Lightly Loaded Server
HELP	Heavily Loaded Powerful Server
GMR	Global Migration Rule
LMR	Local Migration Rule
CAR	Currently Available Resources

TFR	Total Free Resources
FCFS	First Come First Serve
IaaS	Infrastructure As A Service
PaaS	Platform As A Service
SaaS	Software As A Service
IT	Information Technology
DDOS	Distributed Denial of Attack
QoS	Quality of Service
SLA	Service Level Agreement
EARES-D	Energy-Aware Resource Efficient workflow Scheduling Deadline
ELMWCT	Energy-aware Live Migration algorithm using Workload-aware Consolidation Technique

CHAPTER ONE

INTRODUCTION

This chapter consists of the background of study, problem statement, project objectives and project scope. It provides the description and current issue happen in Cloud computing. It also provides the objective and scopes for this project.

1.1 Background Of Study

Cloud computing is a large distribution of computing paradigm driven by scale economies in which a pool of virtualized, scalable dynamically, managed the power of computing, services, platforms, and storage are delivered on the request to the customer via the Internet (Calheiros, Ranjan, Beloglazov, & Rose, 2011). Cloud computing trends are expanding as cloud services become a part of our industry. This is because Cloud computing is a reliable service delivered through a next-generation data center that erected on the computing and storage virtualization technology. The storage is not set up on the local computer but it operates on centralized facilities managed by third-party services (Bakshi, n.d.). The application and data from the Cloud are easily accessible and always available to users anytime and anywhere in the world. Cloud appears to be an access point for all consumer computing needs.

The growth of cloud computing may lead to some negative impact on our environment. High energy consumption is one of the major issues in cloud computing. In the cloud, data centers typically use as many energy as 25000 households (Joy, Chandrasekaran, & Binu, 2016). Recently, the datacenters use about 2% of the world's energy output, which produces more than 43 million tons of CO_2 a year (Arroba, Moya, Ayala, & Buyya, 2015). Moreover, the factor of VM allocation across servers may affect energy utilization. Due to that, cloud applications consume large amounts of energy which has resulted in a negative impact on the environment due to the emission of carbon dioxide. Therefore, green cloud computing is required to protect the environment by reducing energy consumption (Kurdi, Alismail, & Hassan, 2018).

Locust-inspired scheduling algorithm is to reduce the amount of energy consumption in Cloud datacenter (LACE). In LACE, the scheduling policy is distributed among heterogeneous server which each server is responsible for allocation and migration of VM. Every running server should work for the maximum VMs number. Then, VM is transferred to another server then the idle servers can be turned off to save up the energy when the VMs number executed on the server drop to a certain threshold. This algorithm is performed based on the behavior of locust phase changes in nature.

The locust behaviour can change flexibly between two opposite phases which are a solitary phase and gregarious phase based on the certain condition. The solitary phase is the normal phase where locusts live by their own and eat grass when hungry. When the number of locusts grows up to its fullness, the phase will change to the gregarious phase. The gregarious phase is the phase where each locust becomes gluttonous and eat excessively on the grass and sometimes also on weaker locust. Then, the locust returns to the solitary phase when the locust population becomes less. Both phases happen when the locust finding their food to eat. The solitary phase is act as a mapping phase while the gregarious phase is consolidation or migration phase in locust nature. These phases can be applied to LACE algorithm which emulates the locust behavior to consolidate VMs into the server then the server turns off to become the idle server.

The existing LACE algorithm is implemented in 400, 600, 800 and 1000 servers only. In the benchmark paper, the result of energy consumption for 400, 600, 800 and 100 servers are plotted in distinct graphs. Moreover, it does not consider the implementation in huge number of servers. In this work, the results from different number of servers are plotted within one graph to evaluate and compare the energy efficiency. Besides that, LACE algorithm is implemented in huge number of servers in one Cloud datacenter. The LACE algorithm is executed in 1000, 2000, 3000 and 4000 servers to see the performance in Cloud datacenter. The extensive implementation use same number of workloads which 500 to 3700 and same parameter settings. This is to evaluate the level of energy consumption between huge number of servers in the same environment.

1.2 Problem Statement

The existing LACE algorithm is implemented in 400, 600, 800 and 1000 servers within one Cloud datacenter (Kurdi et al., 2018). The number of VMs represent the load are 500, 900, 1300, 1700, 2100, 2500, 2900, 3300 and 3700. The results only show the performances of LACE algorithm in 400, 600, 800 and 1000 servers to determine the level of energy consumption. The main problem is no evaluation or comparison between the results of LACE algorithm in datacenter has been made. The benchmark paper only considers to show the results in distinct graphs. Moreover,

no extensive implementation has been made to evaluate the performance of LACE algorithm in huge number of servers within one Cloud datacenter in the benchmark paper. The implementation of LACE algorithm need to be executed using same number of VMs in huge number of servers such as 1000, 2000, 3000 and 4000. The evaluation need to be made to ensure whether the implementation of LACE in huge number of servers can decrease the consumption of energy or not.

1.3 Research Objectives

The objectives that can be found in this proposed paper are

- To compare the results of implementation LACE algorithm in 400, 600, 800 and 1000 servers within a Cloud datacenter.
- To evaluate the implementation of LACE algorithm in a huge number of servers within one cloud datacenter.

1.4 Research Scope

The scopes that can be found in this proposed paper are

- Green cloud research area that focuses on dynamic VM allocation in servers within one cloud datacenter.

REFERENCES

Adrian, B., & Computing, A. C. (2015). Analysis of K-means Algorithm For VM Allocation in Cloud Computing. *2015 International Conference on Data and Software Engineering (ICoDSE)*, 48–53. https://doi.org/10.1109/ICODSE.2015.7436970

Alnajdi, S., Dogan, M., & Al-qahtani, E. (2016). A S URVEY ON R ESOURCE A LLOCATION IN C LOUD C OMPUTING, *6*(5), 1–11. https://doi.org/10.5121/ijccsa.2016.6501

Arroba, P., Moya, J. M., Ayala, J. L., & Buyya, R. (2015). DVFS-Aware Consolidation for Energy-Efficient Clouds. *Parallel Architectures and Compilation Techniques - Conference Proceedings, PACT*, 494–495. https://doi.org/10.1109/PACT.2015.59

Bakshi, A. (n.d.). Securing cloud from DDOS Attacks using Intrusion Detection System in virtual machine, (fig 1).

Calheiros, R. N., Ranjan, R., Beloglazov, A., & Rose, A. F. De. (2011). CloudSim : a toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms, (August 2010), 23–50. https://doi.org/10.1002/spe

Grover, J., & Sharma, M. (2014). Cloud Computing and Its Security Issues - A Review. *Fifth International Conference on Computing, Communications and Networking Technologies (ICCCNT)*, 1–5. https://doi.org/10.1109/ICCCNT.2014.6962991

Hlatshwayo, C. M., & Zuva, T. (2016). Mobile Public Cloud Computing , Merits and Open Issues. *2016 International Conference on Advances in Computing and Communication Engineering (ICACCE)*, 128–132. https://doi.org/10.1109/ICACCE.2016.8073736

Ighare, R. U., & Thool, R. C. (2015). Threshold based Dynamic Resource Allocation using Virtual Machine Migration, *5*(4), 2603–2608.

Joy, N., Chandrasekaran, K., & Binu, A. (2016). Energy aware SLA and green cloud federations. *2016 IEEE International Conference on Distributed Computing, VLSI, Electrical Circuits and Robotics, DISCOVER 2016 - Proceedings*, 7–11. https://doi.org/10.1109/DISCOVER.2016.7806217

Kaur, R., & Kaur, J. (2015). Cloud Computing Security Issues and its Solution : *2015 2nd International Conference on Computing for Sustainable Global Development (INDIACom)*, 1198–1200.

Kiruthika, J. (2013). System Performance in Cloud Services : Stability and Resource Allocation. *2013 12th International Symposium on Distributed Computing and Applications to Business, Engineering & Science*, 127–131. https://doi.org/10.1109/DCABES.2013.30

Kumar, R., Kumar, A., & Sharma, A. (2016). A Bio-inspired Approach for Power and Performance Aware Resource Allocation in Clouds. *MATEC Web of Conferences*, *57*, 0–5. https://doi.org/10.1051/matecconf/20165702008

Kurdi, H. A., Alismail, S. M., & Hassan, M. M. (2018). LACE: A Locust-Inspired Scheduling Algorithm to Reduce Energy Consumption in Cloud Datacenters. *IEEE Access*, *6*, 35435–35448. https://doi.org/10.1109/ACCESS.2018.2839028

Lee, E. K., Member, S., Viswanathan, H., & Member, S. (2017). Proactive Thermal-Aware Resource Management in Virtualized HPC Cloud. *IEEE Transactions on Cloud Computing*, *5*(2), 234–248. https://doi.org/10.1109/TCC.2015.2474368

Li, S., & Gao, J. (2016). Moving from Mobile Databases to Mobile Cloud Data Services. *2015 3rd IEEE International Conference on Mobile Cloud Computing, Services, and Engineering*, 235–236. https://doi.org/10.1109/MobileCloud.2015.33

Liao, D., Sun, G., Anand, V., Liao, D., Lu, C., Zhang, X., & Bao, N. (2014). Power-Efficient Provisioning for Online Virtual Network Requests in Cloud-Based Data Centers Power-Efficient Provisioning for Online Virtual Network Requests in Cloud-Based Data Centers, (January). https://doi.org/10.1109/JSYST.2013.2289584

Patel, Y. S., Mehrotra, N., & Soner, S. (2015). Green Cloud Computing : A Review on Green IT Areas for Cloud Computing Environment. *2015 International Conference on Futuristic Trends on Computational Analysis and Knowledge Management (ABLAZE)*, 327–332. https://doi.org/10.1109/ABLAZE.2015.7155006

Qureshi, S. S., Ahmad, T., & Rafique, K. (n.d.). MOBILE CLOUD COMPUTING AS FUTURE FOR MOBILE APPLICATIONS - IMPLEMENTATION. *2011 IEEE International Conference on Cloud Computing and Intelligence Systems*, 467–471. https://doi.org/10.1109/CCIS.2011.6045111

Rahman, A. U., Khan, F. G., & Jadoon, W. (2016). Energy Efficiency techniques in cloud computing, (July).

Rajani, V. (2016). A VM Allocation Strategy for Cluster of Open Host in Cloud Environment. *2016 International Conference on Advanced Communication Control and Computing Technologies (ICACCCT)*, (978), 569–572. https://doi.org/10.1109/ICACCCT.2016.7831704

Roy, S., & Gupta, S. (2014). The green cloud effective framework: An environment friendly approach reducing CO<inf>2</inf> level. *2014 1st International Conference on Non Conventional Energy (ICONCE 2014)*, (Iconce), 233–236. https://doi.org/10.1109/ICONCE.2014.6808718

Selvi, S. T., Valliyammai, C., & Dhatchayani, V. N. (2014). Resource Allocation Issues and Challenges in Cloud Computing. *2014 International Conference on Recent Trends in Information Technology*, 1–6. https://doi.org/10.1109/ICRTIT.2014.6996213

Shen, H., Member, S., & Chen, L. (2018). CompVM : A Complementary VM Allocation Mechanism for Cloud Systems. *IEEE/ACM Transactions on Networking*, *26*(3), 1348–1361. https://doi.org/10.1109/TNET.2018.2822627

Wang, J. V, Cheng, C., & Tse, C. K. (2015). A Power and Thermal-Aware Virtual Machine Allocation Mechanism for Cloud Data Centers. *2015 IEEE International Conference on Communication Workshop (ICCW)*, 2850–2855. https://doi.org/10.1109/ICCW.2015.7247611

Yamini, R. (2012). Power Management in Cloud Computing Using Green Algorithm. *IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM -2012)*, 128–133.

Zaman, S., & Grosu, D. (2012). An Online Mechanism for Dynamic VM Provisioning and Allocation in Clouds. *2012 IEEE Fifth International Conference on Cloud Computing*, 253–260. https://doi.org/10.1109/CLOUD.2012.26

Zhu, H., Wang, X., & Wang, H. (2015). A new model for energy consumption optimization under cloud computing and its genetic algorithm. *Proceedings - 2014 10th International Conference on Computational Intelligence and Security, CIS 2014*, 7–11. https://doi.org/10.1109/CIS.2014.171

Zulkernine, M. (2017). A Reliability-Based Resource Allocation Approach for Cloud Computing, 249–252. https://doi.org/10.1109/SC2.2017.46