AN IMPROVED DYNAMIC LOAD BALANCING FOR VIRTUAL MACHINES IN CLOUD COMPUTING USING HYBRID BAT AND BEE COLONY ALGORITHMS

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A thesis submitted in
fulfilment of the requirement for the award of the
Doctor of Philosophy

Faculty of Computer Science and Information Technology
Universiti Tun Hussein Onn Malaysia

August 2021

In the name of Allah, the Beneficent, the Merciful
I dedicate this thesis to my family members for their encouragement and prayers, despite the hard time they went through, which gave me the strength to withstand the obstacles embedded throughout my academic struggles. I dedicate this thesis to my parents for their understanding, encouragement, and prayers to my success, despite their old age. I dedicate it to my brother and friends that contributed immensely to the ideas used in this study.

ACKNOWLEDGEMENT

In the name of Allah, the Beneficent, the Merciful. All praise goes to Almighty ALLAH, the Most Gracious and the Most Merciful, who created the universe and appointed the man as His vicegerent. I offer humble thanks to ALLAH who blessed and give me the courage and power to complete this dissertation. All the blessing to His Prophet Muhammad (peace be upon him), who is the source of knowledge and guidance for humanity.

Special appreciation goes to my supervisor Prof. Dr. Nazri Mohd Nawi who supervised the work up to its completion. I am also expressing my appreciation to the examiners whose constructive comments and observation improved the quality of the research to meet up with the required standard.

Sincere gratitude goes to my mother for her immense support, love, and prayers. I would essentially have not been able to achieve this noble goal without their kindness and prayers. I wish to express my appreciation for their love and affection on me in every aspect of life.

I would like to express my profound admiration to my brothers. It is impossible to describe in words how much you have done for me to go this far without your support. I would like to acknowledge a valuable pat on my back of my friends.

ABSTRACT

Cloud technology is a utility where different hardware and software resources are accessed on pay-per-user ground base. Most of these resources are available in virtualized form and virtual machine (VM) is one of the main elements of visualization. In virtualization, a physical server changes into the virtual machine (VM) and acts as a physical server. Due to the large number of users sometimes the task sent by the user to cloud causes the VM to be under loaded or overloaded. This system state happens due to poor task allocation process in VM and causes the system failure or user tasks delayed. For the improvement of task allocation, several load balancing techniques are introduced in a cloud but stills the system failure occurs. Therefore, to overcome these problems, this study proposed an improved dynamic load balancing technique known as HBAC algorithm which dynamically allocates task by hybridizing Artificial Bee Colony (ABC) algorithm with Bat algorithm. The proposed HBAC algorithm was tested and compared with other state-of-the-art algorithms on 200 to 2000 even tasks by using CloudSim on standard workload format (SWF) data sets file size (200kb and 400kb). The proposed HBAC showed an improved accuracy rate in task distribution and reduced the makespan of VM in a cloud data center. Based on the ANOVA comparison test results, a 1.25 percent improvement on accuracy and 0.98 percent reduced makespan on task allocation system of VM in cloud computing is observed with the proposed HBAC algorithm.

ABSTRAK

Teknologi awan adalah utiliti di mana sumber perkakasan dan perisian yang berbeza dicapai berdasarkan asas pembayaran setiap pengguna. Sebilangan besar sumber ini terdapat dalam bentuk maya dan mesin maya (VM) adalah salah satu elemen utama visualisasi. Dalam virtualisasi, pelayan fizikal berubah menjadi mesin maya (VM) dan bertindak sebagai pelayan fizikal. Oleh kerana jumlah pengguna yang banyak kadang-kadang tugas yang dihantar oleh pengguna ke sistem awan menyebabkan VM berada di bawah beban atau berlebihan beban. Keadaan sistem ini berlaku kerana proses peruntukan tugas yang lemah di VM dan menyebabkan kegagalan sistem atau tugas pengguna tertunda. Untuk meningkatkan peruntukan tugas, beberapa teknik pengimbangan beban diperkenalkan di awan tetapi masih berlaku kegagalan sistem. Oleh itu, untuk mengatasi masalah ini, kajian ini mencadangkan teknik pengimbangan beban dinamik yang lebih baik yang dikenali sebagai algoritma HBAC yang secara dinamis memperuntukkan tugas dengan menghibridisasikan algoritma *Artificial Bee Colony* (ABC) dengan algoritma *Bat*. Algoritma HBAC yang dicadangkan diuji dan dibandingkan dengan algoritma canggih yang lain pada 200 hingga 2000 tugas dengan menggunakan perisian CloudSim pada format data *standard workload* (SWF) set ukuran fail (200kb dan 400kb). HBAC yang dicadangkan menunjukkan peningkatan tahap ketepatan dalam pengagihan tugas dan mengurangkan jangka waktu VM di pusat data awan. Berdasarkan hasil ujian perbandingan ANOVA, peningkatan ketepatan sebanyak 1.25 peratus dan penurunan jangka masa 0.98 peratus pada sistem peruntukan data VM dalam pengkomputeran awan diperhatikan dengan menggunakan algoritma HBAC yang dicadangkan.

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LIST OF SYMBOLS AND ABBREVIATIONS

DC	-	Data center
VM	-	Virtual machine
DCBT	-	Divide-and-Conquer and Throttled algorithms
SI	-	Swarm intelligent
FM	-	Frequency Modulated
CF	-	Constant frequency
VMM	-	Virtual machine Memory Management
QOS	-	Quality of service
NDC	-	Number of data center
Nh	-	Number of host
Tm	-	Type of manager
NPth	-	Number of Processing Time per Host
Bw	-	Bandwidth
Hm	-	Host Memory
Dcc	-	Datacenter Cost
MIppt	-	Million instruction per second of Processing Time
VM	-	VM Memory
CJmax	-	Total number of Tasks
PTAjvm	-	Maximum completion time of task
CJVm	-	Processing time of all tasks in VM
CTsvm	-	Completion time of single task on machine
CTvm	-	Completion time of all task on machine
PTstvm	-	Processing time of single tasks in VM
PTtvm	-	Processing time of all tasks in VM
NRpp	-	Number of requests per period
Ppn	-	Priority per node
CC	-	Cloud computing

HBAC	-	Hybrid BAT and Artificial intelligent bee colony
Avg DC	-	Average Data center time
Min DC	-	Minimum Data center time
Max DC	-	Maximum Data center time
iT	-	Iteration Of Algorithm

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Cloud computing is an innovative technology that has been significantly enhanced in the past decade to deliver virtualized IT services over the internet (Sinha, 2012). Instead of providing IT services and resources locally, cloud computing facilitates the sharing of the resources and services over the internet (Koubaa *et al*., 2019). Cloud resources are providing universal tools and any user can subscribe or provide this service with the help of the internet. Owing to the provision of cloud services on high bandwidth communication and low-cost computing with storage, cloud computing has become a successful 21st century technology (Markovic *et al*., 2013). Cloud computing architecture can be divided into three types of services; (a) platform, (b) software, and (c) infrastructure. These cloud computing architectures help user in resources management and getting their required application (Manvi and Shyam, 2014). There are four common types of cloud computing services i.e. private, hybrid, public, and community. Different operators and organizations use cloud computing services according to their demand and requirement (Diaby and Rad, 2017).

On demand services provided by cloud computing, it has led to be highly utilized in education, geospatial sciences, engineering, data-intensive applications, health and life sciences, application programming services, and business domains (Buyya and Sukumar, 2011). According to Gupta *et al*., (2013) the main advantages of cloud computing are cost reduction, data security, scalability, mobility, disaster recovery, control and competitive edge.

Due to these features, it has become more reliable technology that is growing rapidly while maintaining rich resources and services. It is also called the fifth generation of computing after mainframe, personal and client services. Nowadays, different cloud services are available in a distributed manner but the use of these services can become a big issue; and sometimes resources can be poorly utilized which leads us towards cloud management activities (Hassanzadeh, 2016).

Cloud computing is recently offering a huge amount of benefit to the clients and companies by providing plenty of storage option and access to different resources without additional costs. The main characteristics of cloud computing are virtualization, availability, large network access, automatic system, economics, security, measured service and scalability (Silberschatz *et al*., 2018). According to Afolabi *et al*., (2018), virtualization is the process in which physical instance of single application or resource sharing among multiple organization or users. This technique is done by assigning physical resources in a virtual form. Virtualization plays an important role in cloud computing for sharing data as an application as well as sharing the infrastructure.

Furthermore, the main element of virtualization is known as virtual machine (VM). VM is a software program that emulates the real behavior of the server or a separate computer. Different rules and policies of the system are implemented in the VM development process. With the help of these rules and policies, VM work more efficiently. When a user sends or requests for data in a cloud, all requests move to either one VM or several VM’s which can lead towards a phenomenon called under-loaded VM or overloaded VM. An under loaded VM consumes more power but overloaded VM leads us towards failure of the system, delay in a user’s task or both. Therefore, load balancing techniques are used to balance task allocation for VM’s in a cloud computing infrastructure (Lagar *et al*., 2009). Equation (1.1) shows the under-loaded, overloaded and balanced condition for a VM. If the first two conditions occur in a virtual machine it means it needed a proper dynamic load balancing to improve the performance of the network.

$$f\ (VM)\{</Ti - \sum_{V=1}^{K} Lv \quad Underloaded\ > /Ti - \sum_{u=1}^{K} Lv \quad Overloaded$$
$$= /Ti - \sum_{i=1}^{K} Lv \quad Balanced \qquad (1.1)$$

where, T_i present the given task, K is the capacity of VM where given data are compared with these values (i-e),i,u, $v.and\ Lv$ load value.

Dynamic load balancing (DLB) is a technique used in cloud computing for the management of a resource or task in such a way that maximum throughput is achieved with slightest reaction time. Also, the division of the traffic between different VM's is improved and user is able to get data without any delay (Sakr *et al*., 2011). DLB is one of the main factors of optimizing network performance (Greenberg *et al.*,2008). According to Menasche and Vanneaux (2016), load balancing is founded on the following parameters:

(a) ***Performance;*** the effectiveness system performance must be validated after implementing the technique as compared with other existing techniques for load balancing.

(b) Response time; time taken to complete request on the system is known as response time.

(c) Throughput; the total amount of submitted task or process in a unit of time on the system. The higher the throughput, the better system performs.

(d) Scalability; the capacity of the system to accomplish uniform load balancing when the system increases in terms of the user.

(e) Fault tolerance; the capacity of load balancing to uniformly perform in case of a breakdown of any link.

(f) Migration time; the time taken to transfer task from under-loaded machine to overloaded machine; the lower time taken the better performance the system.

(g) Resource user; to ensure that all the resources are properly used in the cloud system and minimizing overall cost.

(h) Degree imbalance; Degree imbalance is process when physical server gets overloaded then its load is shifted to a VM.

(i) Makespan; to present the total time or completion time that allocates the resource to a user as shown in the Equation (1.2).

$$\text{Makespan}=Mix\ \left[CT_{ij}\right]\ i\epsilon\ t,....i...nJ \in VM\ where\ j=1,\ 2......m \qquad (1.2)$$

where,

t_{ij} is the start time of job j is the performance on machine *i and t* is time.

M_{ix} be minimum makespan (finished time of job) on machine

$CT\ is\ the\ complete\ task$

(j) Network stability; the performance of the network is measured by the number of jobs completed in a proper way with proper bandwidth. Equation (1.3) shows the formula for network stability.

$$V = \lambda(1-P)^{-1} = \lambda N \qquad (1.3)$$

where,

Network with N queue with external rate $\lambda i,$

The system is denoted as $\lambda = (\lambda_1, \lambda_2, \lambda_3, \dots, \lambda_n)$

These are the parameters which are used to check the performance of load balancing technique in a cloud environment and $(1-P)^{-1}$ means non-negative or data not reached to the destination (Thakur *et al.*, 2017).

Initially, Zhao *et al.*, (2008) and Thombare *et al*., (2010) used a traditional load balancing approach which works on the basis of no priority rule for any parameters. Although it was simple technique but it was ineffective and prone to error for task allocation in VM's. For task allocation in VM, priority is very important and different priority rules are applied for task allocation in a cloud. Seeing the prowess of modern heuristics in the recent decade, researchers shifted from conventional allocation algorithms to metaheuristic algorithms. Rathore *et al.,* (2015) used ABC algorithm for improvement in task allocation system in a cloud. Normally VM become under/overloaded due to the distribution system or fitness value of ABC algorithm. Therefore, the author checks the fitness status of VM in confinement at intervals to update the task allocation to different VM's. Kruekaew and Kimpan (2014) tried to improve the load balancing by decreasing the makespan and increasing the task accuracy with ABC.

Therefore, the author modified ABC algorithm at fitness value for load balancing as well as VM load calculation. Later, Babu *et al*., (2015) modified ABC algorithm's initialization phase to avoid ABC getting entrapped in the local optimum due to its poor exploitation. From the literature, it seems that ABC algorithm is efficient and effective for task allocation system in cloud computing using load balancing approach however the elucidation search equation issue still exists due to which exploitation and exploitation problem occur. According to Verma *et al*., (2012), due to the exploitation issue in ABC algorithm that highly affects the overall optimization process. Bansal *et al*., (2016) also reported poor task distribution to VM's due to poor exploitation in ABC algorithm. Recently, Bat algorithm is found to provide better results in task allocation due to its prowess in exploration and exploitation which due to the updation rule (Verma, *et al*., 2016). Therefore, this study proposed an improved load balancing technique by hybridizing artificial bee colony algorithm with Bat algorithm where in searching food source, employed bee's share the information about the food source to onlooker bee. In the initialization section, equal number of employed bees and onlooker bees used the same updation rule for searching process which make trapping in search process cannot be avoided. Therefore, for employed bee the Bat updation rule is used in initialization section. When the employed bees share the information with onlooker bee with the help of dancing, it helps the onlooker bee to prepare the candidate bee for searching process. Onlooker bees start searching for candidate bee using a technique where it takes cycle for searching bee particularly if some tasks are missing in this cycle. Moreover, it takes more cycle in making sure all tasks are cover in the searching process. This technique takes more time and for that reason a new technique is needed in onlooker searching section which can make the task into equal part so that the process of searching can be start which will be more effective and take less time. Two main parameters are used to check the proposed algorithm which are makespan and task accuracy.

1.2 Problem Statement

Various research advancement took place in the field of dynamic load balancing technique in cloud computing. However, researchers still face issues like under and overloads of task in VM's for cloud data centers. Which effect different quality of services like accuracy of task and makespan. Although researchers have addressed this issue in the past, most of them do not consider the important of checking sub-optimal makespan in term of average response time of task in datacenter (DC), average response time of algorithm, average response time of VM and task accuracy rate in cloud datacenter. Chaczko *et al.*, (2012) and Mondal *et al.,* (2015) used activity-based algorithm to overcome these issues. Even though improvement was carried out but due to simple rule there was no priority given for any parameter and it concepts were very simple implementations without error. As a result, it delayed some of important task or it effect the distribution of task in VM which cause the network life time increase. Therefore, researchers shifted from traditional approach to meta-heuristic algorithm for improvement of DLB in VM for cloud computing which provides better result.

Some of the researcher used meta-heuristic approaches like ABC (Babu and Samuel, 2016), Modified ABC (Santhi and Nandhini, 2016), and Bat (Yang and He, 2013) for load balancing in VM's in cloud data centers. Although the ABC algorithm is efficient and effective for DLB, the updation rule equation used in ABC is deemed inefficient for employer and onlooker bee thus leading towards stagnation and time consumption during resource allocation (Kimpan, *et al*., 2016) and delays data processing (Bansal, *et al*., 2016). Therefore, this study proposed an improved ABC algorithm to solve task allocation system in VM using load balancing approach. The resultant Hybrid Bat with Artificial Bee Colony (HBAC) algorithm, utilizes the updation rule section of employed the Bat algorithm updation rule used to improve search section problem in ABC algorithm. Second modification focuses at onlooker search section which reduces time consumption. Last step of the proposed method find a fine balance section in load balancer process. The proposed HBAC algorithm improves two main parameters of load balancing technique, i.e. (a) makespan, in-terms of average response time of algorithm, average response time of cloud datacenter, average response time of VM and (b) task accuracy rate in a cloud datacenter.

1.3 Research Objectives

This study embarks on the following objectives:

(i) To study the effect of meta-heuristic techniques on load balancing for task allocation in virtual machines (VM) for cloud computing.

(ii) To propose an improved dynamic load balancing technique known as (HBAC) by hybridizing Bat with ABC algorithm for enhancing makespan and accuracy parameters.

(iii) To validate the performance of the proposed HBAC algorithm in (ii) by comparing with the existing meta-heuristics (i.e. ABC, Bat, human-based genetic algorithm (HBGA) and Hybrid Branch bound Local Binary Pattern (HBB-LBP) by using CloudSim developed by (Calheiros *et al*., 2011). On standard workload format (SWF) datasets in terms of makespan and accuracy.

1.4 Scope of the Research

This study focuses on improving the dynamic load balancing technique for cloud computing. The improvement is based on makespan and accuracy parameter of load balancing technique in cloud computing. The performance of the proposed HBAC algorithm is compared with state-of-the-art algorithms such as ABC, Bat, HBGA, and HBB-LBP algorithm. Standard workload format (data logs) tested datasets are used to check the performance of these algorithms for task allocation in VM's using dynamic load balancing in cloud computing.

1.5 Significance of the research

This research provides the following contributions in the field of cloud computing.

(i) The proposed HBAC algorithm provides enhanced dynamic load balancing in a cloud computing for task allocation system in VM.

(ii) The proposed HBAC algorithm improves makespan and accuracy parameter of dynamic load balancing technique in a cloud VM.

(iii) The proposed HBAC algorithm improves resource allocation in term of average response time of datacenter and algorithm iteration.

1.6 Outline of the Thesis

This thesis is organized into five chapters. Chapter 1 starts with the basic introduction of cloud computing along with its type, architecture, application and advantages. Then the chapter explains the context and motivation of this work describing the need of optimization in load balancing in VM's. This chapter also discusses the problems in the current techniques for load balancing and proposes an improved HBAC algorithm to overcome the current problems. This chapter is concluded by discussing the objectives, scope and the significance of the study. Chapter 2 presents the literature reviews on cloud computing, its types, and applications. The chapter addresses virtualization as the main element in the virtual machine. Then the chapter discusses the load balancing and its types and algorithms that been used by the previous researchers. The chapter also discusses related works which lead towards finding research gaps and the need for an improved metaheuristic algorithm to overcome that gap. Chapter 3 presents data center and its elements, followed by the standard framework of the ABC algorithm and its parameter. Then, the chapter presents the framework of the proposed HBAC algorithm for load balancing in VM's. Chapter 4 discusses on simulator tool and its parameters which are used during different experiments step. The chapter then compares the proposed technique results with four comparison algorithms. The chapter presents two main parameters of balancing technique that have been used to check the performance of the system which are makespan in-terms of average response time of algorithm, average response time of cloud datacenter, average response time of VM and task accuracy rate in a cloud datacenter. Final section of the chapter presents the comparison results of all algorithms. Last but not least, Chapter 5 presents the contribution of entire thesis along with summary of the thesis before concluding on the future implementations on the proposed HBAC algorithm in different scientific fields.

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