
UNIVERSITI PUTRA MALAYSIA

# PERFORMANCE-AWARE COST-EFFECTIVE BROKERING AND LOAD BALANCING ALGORITHMS FOR DATA CENTER IN LARGE SCALE CLOUD COMPUTING

RANESH KUMAR NAHA

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By

RANESH KUMAR NAHA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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## DEDICATIONS

*To my beloved*
*Mother and Father*

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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 Science

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March 2015

**Chairman: Professor Mohamed Othman, PhD**
**Faculty: Computer Science and Information Technology**

The cloud computing transforms computing services into "as a service" form. It helps organization to reduce computing infrastructure cost. In cloud computing concept, cloud users can use computing resources according to their needs and requirements. Customers are able to scale hardware, software and application platform through Service Level Agreements (SLAs) in the cloud. In recent years, there has been an increasing interest in cloud computing among service providers and cloud users. To provide services, different cloud service providers build their own computing platform differently due to the lack of a common standard. From Day to day it becomes very challenging to select an appropriate provider considering the specific user requirements. Besides the standardization service, one of the most significant current discussions in cloud computing is the cloud brokering service. Cloud brokering is having a positive impact in choosing an appropriate provider along with the capability to handle cloud-to-cloud communication. Cloud brokering is an intermediate negotiator between users and service providers. This negotiator helps users to select appropriate provider as their requests. Questions have been raised about the efficiency of cloud brokering in various aspects of user requirements, such as cost, timeliness, or service performance. However, there has been little discussion about efficient cloud brokering services.

We studied how brokering algorithms improves brokering performance. Through our research we found that cloud brokering algorithms and service



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load balancing algorithms able to improve brokering performance. The aim of this research is to propose a load balancing algorithm and propose cloud brokering algorithms in order to improve brokering performance. Proposed cloud brokering algorithms works with different types of cloud provider and deal with various user requirements. Proposed Cost Aware algorithm minimizes approximately 5.5% cost compared with closest data center algorithm. However, data center processing time response time was greatly increased. Further we developed Load Aware algorithm which minimizes average DC processing time and maximum DC processing time by 73% and 49% respectively. In order to make our proposed method cost efficient, we developed Load Aware Over Cost algorithm which is 8% cost effective comparing with Load Aware algorithm. This algorithm improves average response time by 43%. For all algorithm combinations our proposed State Based Load Balancing algorithm minimizes both processing time and response time.

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**KEBERKESANAN PRESTASI PENGATURAN KOS SEDAR DAN ALGORITMA IMBANGAN BEBAN UNTUK PUSAT DATA PENGKOMPUTERAN AWAN DALAM SKALA BESAR**

Oleh

**RANESH KUMAR NAHA**

**Mac 2015**

**Pengerusi: Profesor Mohamed Othman, PhD**
**Fakulti: Sains Komputer dan Teknologi Maklumat**

Pengkomputeran awan mengubah khidmat pengkomputeran sebagai bentuk "perkhidmatan". Ia membantu organisasi untuk mengurangkan kos infrastruktur pengkomputeran. Dalam konsep pengkomputeran awan, pengguna awan boleh menggunakan sumber komputer mengikut keperluan dan kehendak mereka. Pelanggan boleh mengikut skala perkakasan, perisian dan platform aplikasi melalui Perjanjian Tahap Perkhidmatan (SLA) awan. Dalam tahun-tahun kebelakangan ini, terdapat minat yang semakin meningkat dalam pengkomputeran awan di kalangan pembekal perkhidmatan dan pengguna awan. Bagi menyediakan perkhidmatan, pembekal perkhidmatan awan yang berbezamembina platformpengkomputeranmereka sendiri yang berbeza kerana kekurangan suatu ukuran yang sama. Dari hari ke hari ia menjadi sangat mencabar untuk memilih pembekal yang sesuai dengan mengambil kira keperluan pengguna tertentu. Selain piawaian perkhidmatan, salah satu perbincangan semasa yang paling penting dalamperkomputeran awan adalah perkhidmatan pengaturan awan. Pengaturan awan mempunyai kesan positif dalam memilih pembekal yang sesuai bersama-sama dengan keupayaan untuk mengendalikan komunikasi awan ke awan. Pengaturan awan adalah pengantara perunding di antara pengguna dan pembekal perkhidmatan. Perunding ini membantu pengguna untuk memilih pembekal yang sesuai untuk permintaan mereka. Pelbagai soalan yang telah dibangkitkan mengenai kecekapan pengaturan awan dalam aspek keperluan pengguna, seperti kos, ketepatan masa, prestasi perkhidmatan. Walau bagaimanapun, terdapat sedikit perbincangan mengenai perkhidmatan pengaturan awan yang cekap.

Kami mengkaji bagaimana algoritma pengaturan meningkatkan prestasi pengaturan. Melalui penyelidikan kami, kami mendapati bahawa algoritma pengaturan awan dan algoritma pengimbangan beban perkhidmatan da-

pat meningkatkan prestasi pengaturan. Tujuan kajian ini adalah untuk mencadangkan algoritma pengimbangan beban dan mencadangkan algoritma pengaturan awan untuk meningkatkan prestasi pengaturan. Cadangan algoritma pengaturan awan bekerja dengan pelbagai jenis pembekal awan dan berurusan dengan pelbagai jenis keperluan pengguna. Cadangan algoritma Kos Kesedaran meminimumkan kos kira-kira 5.5% berbanding dengan algoritma pusat data yang berhampiran. Walau bagaimanapun, tindak balas masa pemprosesan pusat data masa telah banyak meningkat. Kami kemudiannya membangunkan algoritma Beban Kesedaran yang mengurangkan purata masa pemprosesan DC dan memaksimumkan masa pemprosesan DC masing-masing sebanyak 73% dan 49%. Dalam usaha untuk membuat kaedah yang kami cadangkan menjadi kos kecekapan, kami membangunkan algoritma Beban Kesedaran Lebihan Kos yang memberikan keberkesanan kos sebanyak 8% dibandingkan dengan Beban Kesedaran algoritma. Algoritma ini meningkatkan masa tindak balas purata sebanyak 43%. Untuk semua kombinasi algoritma kami mencadangkan algoritma Pengimbangan Beban Berasaskan Negeri bagi mengurangkan kedua-dua masa pemprosesan dan masa tindak balas.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| API | Application Programming Interface |
| ARAE | All Resources Are Equal |
| AWRT | Average Weighted Response Time |
| AWS | Amazon Web Services |
| BoT | Bag-of-Tasks |
| CA | Cost Aware |
| CPU | Central Processing Unit |
| CSP | Cloud Service Provider |
| DC | Data Center |
| DLCR | Dynamic Less Consuming Resource |
| EC2 | Elastic Compute Cloud |
| EMO | Multi-objective Optimizer |
| GB | Giga Byte |
| Gbps | Giga Bit Per Second |
| GHz | Gigahertz |
| GICTF | Global Inter-Cloud Technology Forum |
| GMBS | Generic Meta-Broker Service |
| GP | Gluing Platform |
| HPC | High Performance Computing |
| IaaS | Infrastructure as a Service |
| ICT | Information Communication Technology |
| IEEE | Institute of Electrical and Electronics Engineers |
| IMS | IP Multimedia Subsystems |
| ISB | Intercloud Service Broker |
| IT | Information Technology |
| ITU | International Telecommunication Union |
| ITU-T | International Telecommunication Union-Telecommunication |
| KDSWS | Knowledge-based Dynamic Semantic Web Services |
| LA | Load Aware |
| LAOC | Load Aware Over Cost |
| LCR | Less Consuming Resource |
| Mbps | Mega Bit Per Second |
| MIPS | Millions Instruction Per Second |
| NIST | National Institute of Standards and Technology |
| OGF | Open Grid Forum |
| OVMP | Optimal Virtual Machine Placement |
| PaaS | Platform as a Service (PaaS) |
| PT-AR | Per Type-All Resources |
| PT-RR | Per Type-Resources With Result |
| QoS | Quality of Service |
| RAM | Random Access Memory |
| RR | Round Robin |
| SaaS | Software as a Service |



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| | |
|---|---|
| SAGA | Simple API for Grid Applications |
| SALMon | Service Level Agreement Monitor |
| SBLB | State Based Load Balancing |
| SIP | Stochastic Integer Programming |
| SLA | Service Level Agreement |
| SME | Small and Medium Enterprises |
| SPBR | Service Proximity Based Routing |
| SPSB | Service Proximity Service Broker |
| SSV | SLA-based Service Virtualization |
| VM | Virtual Machine |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

The lack of common standards in a fast emerging Cloud computing market over the last years resulted in vendor lock in and interoperability issues across heterogeneous Cloud platforms. Therefore, the Cloud user is facing now a challenging problem of selecting the Cloud provider that fits his needs. A new promising research approach is the use of intermediate broker services to assist the user in finding the appropriate Cloud resources that satisfy his requirements.

This research proposed three cloud brokering algorithms which will reduce execution time as well as operational cost. Cost aware brokering algorithm is the best on cost saving. In other hand, load aware brokering algorithm is best while user is concern about processing and response time. Another algorithm was developed using the method of both algorithms which is called load aware over cost brokering. proposed brokering mechanism implemented in generic simulation framework based on the CloudSim toolkit for the validation and evaluation of a cloud service brokering algorithms deployed on an large cloud environment.

A special type of large data center or a group of data center is the base physical infrastructure for Cloud computing environment. It's may be in one or several geographies. Cloud can be hosted by an enterprise, a government or a service provider (Bernstein et al., 2009, 2011). Content, storage and computing are capable to provide service anywhere in the network, which is called "Intercloud" (Bernstein and Vij, 2010). In interoperability scenario clouds should be find one another for information exchanging.

One of the promising use cases of the Intercloud vision defined in (Buyya et al., 2009) is market transactions via brokers. In such a use case, a broker entity acts as a mediator between the Cloud consumer and multiple interoperable Cloud providers to support the former in selecting the provider that better meets his requirements. Another value-added broker service is the easy deployment and management of the users service regardless of the selected provider through a uniform interface.

The evaluation of the broker using a real testbed is usually cost- and time-consuming, as a large number of Cloud resources is required to achieve realistic results. A more promising and cost-saving approach for the broker evaluation is the use of simulation environments.

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## 1.2 Problem Statement

IT vendor have been introduced public cloud and corporations construct their own private cloud. They are going to offer "pay as you go" model for their consumer. However, cloud federation and interoperation are still in a challenge. The lack of standardization across Cloud providers (Jrad et al., 2012) restricts the deployment of Cloud service brokers on real production Clouds. And this is a challenging task for Cloud developers and researchers. Amongst others, many vendor compatible adapters are needed by the broker to interface the heterogeneous Cloud platforms. Cloud brokering is considered as an interesting research problem.

Interface to monitor, deploy, resume, pause and shutdown of VMs in cloud provided by Cloud broker. This cloud broker deployed using specific independence provider technology. Although there are serveral ongoing efforts, but currently there are no agreed-upon tools to interface with a cloud to carry out these actions, but rather, every provider represents their specific API. Thus, a cloud broker must follow appropriate technique in order to satisfy users specific requirements.
On other hand it is very difficult to choose appropriate resources to meet QoS and unwanted SLA violation which is a big research problem. In order to overcome this problem, further research on cloud brokering and load balancing technique should be undertaken. These technique should be validate in a large scale cloud environments with realistic workload.

## 1.3 Research Objectives

Objectives of this research are:

1. Designing new cloud brokering algorithms.
2. Propose a new load balancing algorithm.

These algorithms will be tested on a simulated environment using various cloud scenarios and also able to manage cloud workload in peak load environment. Moreover, it will enable faster job processing with cost effectiveness.

## 1.4 Research Scope

The scopes of this research are to propose brokering mechanisms and a load balancing algorithms for hybrid cloud data center. After that it will be evaluated in a simulated environment with generated workload. Various cloud provider use different cloud architecture for their services. This research is limited to brokering mechanism and load balancing algorithms without changing existing architecture of cloud providers.



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## 1.5 Research Motivation

Throughout its long history, computer system developed by centralized and decentralized concept. In early stage, computer system was centralized system known as mainframe. These mainframes have massive shared resources used by various users. Later on decentralized system concept highly valued by the consumers due to its cost, and computer system released as personal computer.

In recent years, centralized computer system concept again emerge for technological demand which known as cloud computing. In cloud computing, physical resources are invisible to the users. Even the user is not required to pay high infrastructure cost for their computational needs. Rather than they can pay as they need and it could be for a single hour. The main idea of cloud computing is to deliver system resources to the users through Internet. The underlying infrastructure hosted is a large scale massive data centre with virtualization technology.

Currently there are many organizations offering different services for system hardware infrastructure, software, programming development environment and OS platform through cloud computing. These services most commonly known as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

From various providers it is very difficult to choose appropriate provider by user specific needs. Cloud brokering could be an intermediate platform which helps users to find best fit provider. Unfortunately a few works has done to address this complex problem. From these motivations this work was done on cloud brokering mechanism in order to enhance its brokering performance.

## 1.6 Research Contributions

This research proposed brokering algorithms with load balancing technique for large scale cloud environment. Through broker It enabled consumer mobility. However, it accelerated the initiative of intercloud vision for cloud federation. End users obtained an interworking environment by using different cloud service providers. The key contributions of this research are:

- Proposed cloud brokering algorithms and it could managed cloud workload more efficiently by selecting appropriate provider.
- Proposed load balancing algorithms which minimized processing time.

## 1.7 Thesis Organization

Chapter 2 describes the related works in cloud brokering and load balancing. Chapter 3 describes research methodology used in various experiment



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throughout this research. This chapter stated the basic requirement of the experimental environment and simulation setup. Chapter 4 stated fist findings with results and simulations based on different scenario.

Chapter 5 begins with next finding and next to describes impact of new algorithms in cloud environment. An initial description of all algorithms used in this study described in chapter 4 and 5. These chapter also explained a detailed about experimental results of the simulations. Finally last chapter ends with conclusion and future works. All references, biodata of student and list of publication included at the end of this thesis.



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