UNIVERSITI PUTRA MALAYSIA

QUALITY OF SERVICE MODEL FOR SOFTWARE AS A SERVICE IN CLOUD COMPUTING FROM USERS' AND PROVIDERS' PERSPECTIVES

ATIEH KHANJANI

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By

ATIEH KHANJANI

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

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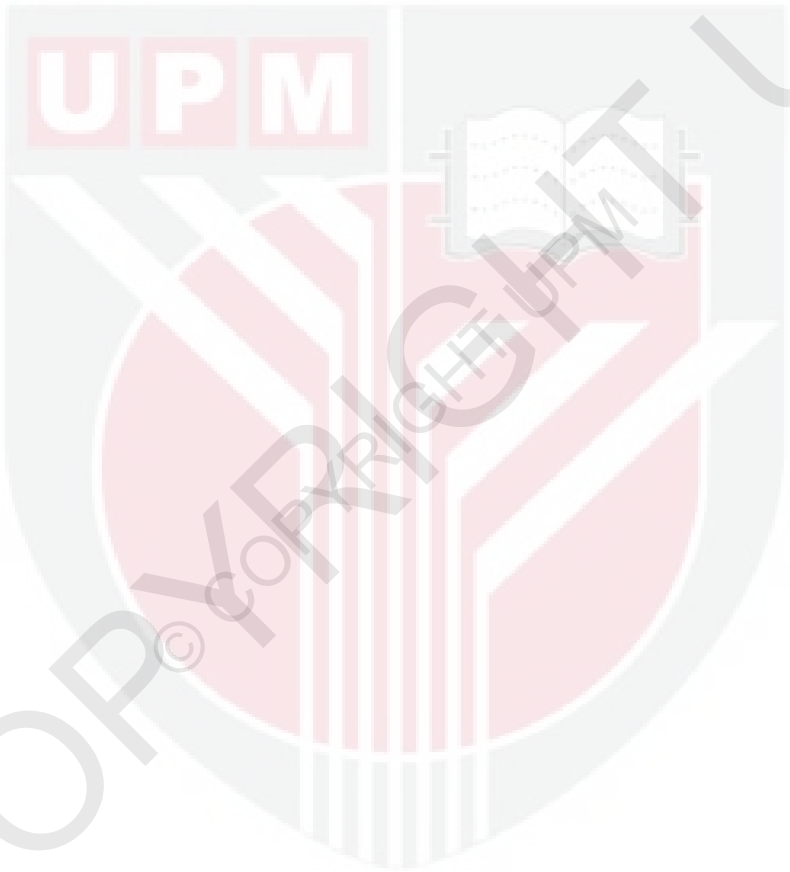
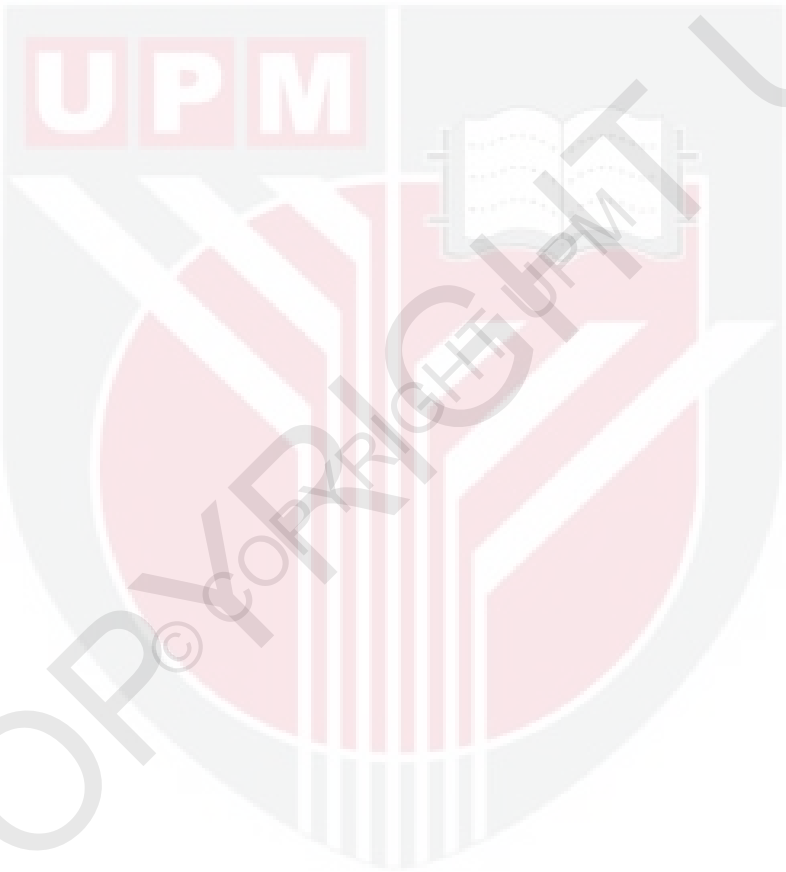


DEDICATION

This thesis is dedicated to:
My wonderful Parents, Mahmoud Khanjani& Homa Mardan



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Doctor of Philosophy

QUALITY OF SERVICE MODEL FOR SOFTWARE AS A SERVICE IN CLOUD COMPUTING FROM USERS' AND PROVIDERS' PERSPECTIVES

By

ATIEH KHANJANI

July 2015

Chairman : Wan Nurhayati Wan Ab. Rahman, PhD
Faculty : Computer Science and Information Technology

Software as a Service (SaaS) is one of the main service models in cloud computing which enables the application to run on the cloud by eliminating the installation on the personal computer at the client side. Quality of Service (QoS) is a crucial factor for the success of cloud services especially in terms of SaaS, so that if it is not delivered as expected, it might blemish the provider's reputation. In this thesis, we address the problem of the lack of QoS model for SaaS to cover more QoS attributes compared to other existing models and their definitions to be referred as reference model which are useful in both users' and providers' perspectives. There is a high demand for creating a quality model for SaaS since conventional frameworks cannot effectively support specific quality aspects of SaaS such as scalability and reusability. Even though there are some studies that have been performed regarding the QoS models for SaaS but they considered only a few attributes and still many aspects are left. Besides, the users might not have sufficient knowledge and experience of what they want and not be able to clarify their requirements very well. Therefore, the QoS consideration should be from both service users' and providers' perspectives to be more effective. In this research, QoS attributes for SaaS cloud services from both users' and providers' perspectives are presented, defined and categorized. A quality model for SaaS called SaaS-QoS model as a reference model to be useful in both perspectives, also was proposed. First, a set of 29 QoS attributes for SaaS cloud from the literature consisted of QoS attributes specific for SaaS quality models and in overall cloud computing, was obtained. Then, a survey conducted through experts in industry, academician and researchers to measure the acceptability of the attributes using purposive sampling technique. Based on the result of the survey, 32 attributes under 5 categories were determined as QoS attributes for SaaS inspired by Service Measurement Index (SMI) framework and the SaaS-QoS model was then proposed. The SaaS-QoS model was evaluated from both user and provider perspectives through performing two surveys by SaaS providers and SaaS users. The results of evaluation part indicated that the categories and attributes assigned are highly associated and relevant. More than that, the SaaS-QoS model is practical and applicable enough for SaaS from both users' and providers' perspectives. This research has given a wider view of QoS attributes to both users and providers as a reference model and also to add to the body of knowledge and practitioners.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

MODEL KUALITI PERKHIDMATAN BAGI PERISIAN SEBAGAI PERKHIDMATAN DALAM PENGKOMPUTERAN AWAN DARIPADA PERSPEKTIF PENGGUNA DAN PENYEDIA

Oleh

ATIEH KHANJANI

Julai 2015

Pengerusi : Wan Nurhayati Wan Ab. Rahman, PhD
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Perisian sebagai Perkhidmatan (SaaS) adalah antara model perkhidmatan utama bagi pengkomputeran awan yang membolehkan aplikasi digunakan pada awan tanpa instalasi pada komputer peribadi di pihak pelanggan. Kualiti Perkhidmatan (QoS) adalah faktor penting bagi kejayaan perkhidmatan awan terutamanya SaaS, sekiranya tidak diberi seperti yang dijangka, ianya akan menjejaskan reputasi penyedia. Dalam tesis ini, kami mengenalpasti masalah kekurangan model QoS bagi SaaS untuk merangkumi lebih banyak atribut QoS dan definisi atribut tersebut berbanding model sedia ada yang dapat digunakan sebagai model rujukan bagi kedua-dua perspektif pengguna dan penyedia. Terdapat permintaan yang tinggi bagi mewujudkan model kualiti bagi SaaS memandangkan rangka kerja konvensional tidak menyokong dengan efektif khususnya aspek-aspek kualiti SaaS seperti skala yang lebih besar dan kebolehgunaan semula. Walaupun terdapat kajian yang telah dilakukan berkenaan model QoS bagi SaaS tetapi mereka hanya mengambil kira beberapa atribut dan masih terdapat banyak aspek yang tertinggal. Di samping itu, pengguna mungkin tidak mempunyai pengetahuan dan pengalaman yang mencukupi bagi menentukan apa yang mereka mahu dan tidak dapat menjelaskan keperluan mereka dengan baik. Oleh itu, pertimbangan terhadap QoS yang lebih efektif adalah perlu dari kedua-dua perspektif penyedia dan pengguna perkhidmatan. Dalam penyelidikan ini, atribut QoS bagi awan SaaS daripada penyedia dan pengguna telah dibentangkan, dikenalpasti dan dikategorikan. Pertama, satu set 29 QoS atribut bagi awan SaaS dan kajian literatur terdiri dan atribut QoS khusus bagi model kualiti SaaS dan secara keseluruhan dari pengkomputeran awan telah dilakukan. Kemudian, kaji selidik dijalankan terhadap pakar-pakar dari industri, ahli akademik dan penyelidik untuk mengukur tahap penerimaan atribut tersebut menggunakan teknik persampelan bertujuan. Berdasarkan keputusan kaji selidik itu, 32 atribut di bawah 5 kategori telah ditentukan sebagai atribut QoS bagi SaaS inspirasi dari rangka kerja Indeks Pengukuran Perkhidmatan (SMI) dan model SaaS-QoS telah dicadangkan. Model SaaS-QoS dinilai dari kedua-dua perspektif pengguna dan penyedia menerusi dua kaji selidik kepada syarikat yang menyediakan SaaS dan pengguna SaaS. Keputusan penilaian mendapati kategori dan atribut yang telah diberikan adalah sangat berkaitan dan relevan. Di samping model SaaS-QoS adalah praktikal dan bersesuaian bagi SaaS dari perspektif pengguna dan penyedia. Penyelidikan ini telah memberikan pandangan yang lebih meluas terhadap atribut QoS kepada kedua-dua pengguna dan penyedia sebagai model rujukan dan dapat menyumbang terhadap badan ilmu dan pihak industri.

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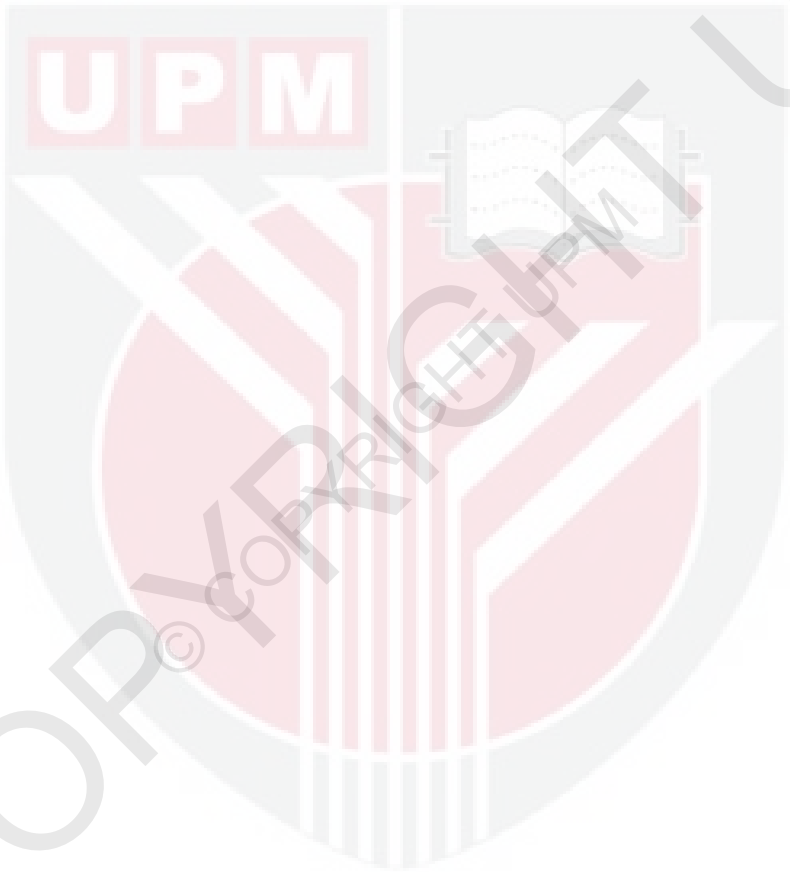
Lastly, I would like to thank all the people who helped and encouraged me to fulfil my PhD thesis.



I certify that a Thesis Examination Committee has met on 13 July 2015 to conduct the final examination of Atieh Khanjani on her thesis entitled "Quality of Service Model for Software as a Service in Cloud Computing from Users' and Providers' Perspectives" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
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Name of Member of Supervisory Committee: Abdul Azim Abd Ghani, PhD	Name of Member of Supervisory Committee: Abu Bakar Md Sultan, PhD

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

QoS	Quality of Service
SaaS	Software as a Service
IaaS	Infrastructure as a Service
PaaS	Platform as a Service
SMI	Service Measurement Index
IT	Information Technology
NIST	National Institute of Standards and Technology
ROI	Return On Investment
EC2	Amazon's Elastic Compute cloud
SLA	Service Level Agreement
KPI	Key Performance Indicator
CSMIC	Cloud Service Measurement Initiative Consortium
SE	Software Engineering
UI	User Interface
ISO	International Organization for Standardization
IEC	International Electronically Commission

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, with merging multi-core processors and distributed computing network environments, software developers tend to use new computing paradigm such as cloud computing to provide easiest way to use computing resources similarly to public utility such as water, electricity and etc. (Buyya et al., 2011). Cloud computing is the best Internet-base computing alternative for handling Information Technology (IT) resources and utilize IT as a service (Rawat et al., 2012). There are three main service categories for cloud computing including Software as a Service (SaaS), Infrastructure as a Service (IaaS) and Platform as a Service (PaaS). Among main services of the cloud, SaaS is the most commonly heard term and one of the important branches of cloud computing which enables the application run on the cloud eliminating the installation on the personal computer at the client side (Marston et al., 2011). From the beginning of using software, the quality of software is taken into consideration. With the prevalence of SaaS cloud and increasing its popularity, considering the QoS as vital factor to distinguish the services from both user's and provider's side and also to user satisfaction and company profitability (He et al., 2012), (La & Kim, 2009). Moreover, QoS is crucial factor for the success of cloud computing so that if it is not delivered properly and as expected, it may tarnish provider's reputation (Ferretti & Ghini, 2010). In addition, SaaS services are multi-tenant, therefore they are dealing with many users with different preferences and profiles and the only way to distinguish these services is to consider QoS from provider as well as user side. Therefore, researchers should pay more attention to the QoS so that the final services provided satisfy customer and bring more benefits to the providers as well. QoS for SaaS cloud services consist of many aspects involved in the business side, network side and service (application) side. Moreover, QoS includes many attributes such as customizability, availability, scalability, performance, supporting multi-tenant and etc. that can be achieved from the specific features of SaaS. Service Measurement Index (SMI) has presented a holistic view of overall cloud services attributes (Garg et al., 2011) and there are some researches which used the SMI attributes to create a QoS model for IaaS. However, although there are some QoS models for SaaS, but they considered only a few attributes and since QoS is very important in any type of cloud services specially SaaS, this motivate us to create a QoS model for SaaS based on SMI framework. Moreover, since SaaS is commonly utilized now and provides advantages rather than traditional software model, so to realize these advantages it is necessary to consider its quality and therefore manage higher level of its quality level according to the evaluation result (Akojwar et al., 2012).

1.2 Research Problems

There is a high demand for creating a quality of service model for SaaS since conventional quality models cannot effectively support specific quality aspects of SaaS such as scalability and reusability (Lee et al., 2009). However, there is a lack of

work on QoS model for SaaS since quality of service models proposed in current researches (Lee, et al., 2009; Nadanam & Rajmohan, 2012) considered a few QoS attributes only and still many aspects such as Suitability, Accuracy, Extensibility, Serviceability, Resilience, Operability and Learnability are left out. The definitions of SaaS QoS attributes are still missing and some are not well-defined. A study showed that the success of cloud services especially SaaS cannot be guaranteed and achieved without user satisfaction especially in terms of QoS (Badidi, 2013). The users, on the other hand, might not have enough knowledge and experience of what they want and not able to clarify their requirements very well. Therefore, the QoS consideration should be from both users' and providers' perspectives to be more effective.

1.3 Research Questions

In order to contribute for proposing solutions to the stated problems, these are the research questions that need to be answered in this research:

- What is the most relevant QoS model for SaaS cloud computing?
- What are the main QoS attributes required for SaaS cloud?
- Why QoS attributes should be considered from both users' and providers' perspectives?

1.4 Research Objectives

The main objective of this study is to propose a quality of service model for SaaS cloud services as a reference model to be used by both users and providers.
The specific objectives of this research are as follow:

- To determine the QoS attributes for SaaS useful for both users and providers;
- To classify the QoS attributes into related category, specifically for SaaS;
- To verify the new definitions of QoS attributes proposed in SaaS-QoS model by experts.

1.5 Research Scope

Cloud computing is a wide range of new computing paradigm. SaaS is a kind of cloud computing services which delivers software applications as an online service usable through the Internet. The quality of SaaS services is crucial for the success of cloud SaaS services. Besides, SaaS has special features which need to be considered when it comes to quality, because the quality of SaaS is different from other types of cloud services. QoS model for SaaS cloud is important to be used by users and providers. Thus, this research is concentrating on proposing QoS model for SaaS. There are five categories for SaaS-QoS model in this research which are Agility, Assurance, Performance, Security and Usability. The categories inspired by SMI framework and every category has three or more QoS attributes.

1.6 Research Contribution

The main contribution of this research is to construct SaaS-QoS model from both users' and providers' perspectives. For this matter, QoS attributes were gathered from literature review and obtained a set of 29 attributes under five categories such as Agility, Assurance, Performance, Security and Usability. Then, the attributes were assigned to the respective categories inspired by SMI framework followed by (Buyya et al., 2011) which used SMI to create QoS for IaaS. A survey was performed to measure the acceptability of attributes and categories. Based on the result, the definition of attributes and categories and the initial SaaS-QoS model was improved and finally the final version of SaaS-QoS model consisted of 32 attributes under five categories was designed. The final version of SaaS-QoS model then, was evaluated by both users and providers through performing two surveys by SaaS providers and users.

1.7 Thesis Organization

This thesis comprises six chapters, including this introductory chapter covering the background of the study, problem statement, research objectives, scope of research, and thesis organization.

Chapter 2 reviews literature on cloud computing concepts, services in cloud computing, software as a service delivery model, importance of QoS in cloud SaaS, SMI and researches on QoS models for cloud computing specially in terms of SaaS. This chapter provides important information to be taken into consideration in an effort to meet the research goal, which is to develop a QoS model for SaaS cloud.

Chapter 3 explains the research methodology comprising constructing the SaaS-QoS model steps such as determining QoS attributes from literature and standard, performing justification for attributes, check for their redundancy, performing a purposive sampling survey for measurement of the acceptability of attributes and performing the second survey to assess the quality of service model constructed.

Chapter 4 expresses the result and outcome of constructing the SaaS-QoS model including determination of the QoS attributes for SaaS cloud, justification for those attributes, check for redundancy and the survey was done for measurement of acceptability of the attributes.

Chapter 5 explains the findings and results of model evaluation including performing a purposive sampling survey from both users' and providers' perspective to evaluate the model. Finally, Chapter 6 presents the conclusion, summary of contribution and future works of this research.

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