UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Engineering and Information Technology

# AI-driven Service Broker for Simple and Composite Cloud SaaS Selection

by

**Mohammed Abdulaziz Ikram**

A Thesis Submitted
in Partial Fulfillment of the
Requirements for the Degree

**Doctor of Philosophy**

Sydney, Australia

2020

# Certificate of Authorship/Originality

I, Mohammed Ikram declare that this thesis, is submitted in fulfilment of the requirements for the award of PhD in Computer System, in the school of Computer Science at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by the Australian Government Research Training Program.

Signature: Production Note: Signature removed prior to publication.

Date: 30/06/2020

# ABSTRACT

**AI-driven Service Broker for Simple and Composite Cloud SaaS Selection**

by

Mohammed Abdulaziz Ikram

Cloud Software as a Service (SaaS) is one of the three types of services offered in cloud computing. Cloud SaaS is a software application that runs on top of Platform as a Service (PaaS), which in turn works on top of Infrastructure as a Service (IaaS). Due to the numerous advantages offered by cloud SaaS to service consumers, such as reducing the cost of IT expenditures, security capabilities and disaster recovery offered by cloud SaaS service providers, Cloud SaaS is becoming a leading and growing type of cloud service among other cloud services (i.e., IaaS and PaaS). Therefore, Cloud SaaS service consumers may face a difficult task when searching for the most suitable service based on their preferences. Service selection is based on matching the service requirements of functional and non-functional quality attributes. However, selecting a Cloud SaaS service provider with a high number of non-functional quality attributes that fulfils consumer requirements within a large number of similar functional services is a key factor for a Cloud SaaS service selection.

In addition, considering that a cloud SaaS service can involve a long-term contract, Cloud SaaS providers frequently offer a free trial period to test and evaluate services before the consumers make the decision of whether they will use that service.Furthermore, selecting multiple Cloud SaaS service providers in order to create a new business value, known as a service composition in the service-oriented architecture (SOA) model, is very important, since Cloud SaaS services are the first option for deploying IT services for many new enterprises.

Therefore, this research aims to propose intelligent methods for a simple and composite service selection framework based on consumer preferences. By simple, we mean a singular service whereas by composite, we mean an aggregated service. This work seeks to find the services with a high number of non-functional quality attributes that meet the consumer requirements. To achieve the objectives of this research, a design science research methodology will be adopted. Fuzzy logic will be proposed to address the uncertainty of consumer preferences. A ranking service system, evaluation system and composite decision maker system are proposed in this thesis to help a Cloud SaaS service consumer select the optimal service required. Multiple approaches of decision-makers will be developed in order to achieve our research objectives. It is expected that this research work will enhance the selection mechanism of Cloud SaaS, either simple or composite based on service consumer's preferences.

Dissertation directed by Associate Professor Farookh Hussain
School of Computer Science
Centre for Artificial Intelligence
Faculty of Engineering and Information Technology (FEIT)

# Dedication

To all of my family...

# Acknowledgements

I am thankful to Allah Almighty, who bless me and support me to write the whole thesis. My greatest gratitude goes to my family, I thank my mother Najah Jalal who taught me to be patient and supported me during the PhD journey. Also, I would like to thank my great father Abdulaziz Ikram who taught me to be responsible. Special thanks to my wife Haneen Ekram, and my kids Janna, Ibrahim and Ahmed for supporting me through all my PhD journey. I would like to express my gratitude to all of my family, my sister and brothers who supported me with motivational words and prayers. Also, special thanks to my daughter Janna who help some parts of my thesis. Without all your love I could never have written my thesis.

I would like to thank my supervisor, Prof. Farookh Hussain for his patient guidance, encouragement and advice from the first day through to the end of my PhD journey. Also, I would like to thank my Co-Supervisor Dr Nabin Sharma for his help and support. I would also like to thank all my colleagues during PhD journey Dr Alshehri, Dr Alshaweesh, Dr Shoria, Dr Supanada, Dr Aysha, Dr Thaqeb, Dr Quen and Dr Yahya. I would particularly like to thank Dr Reza for the suggestions he made in Chapter 5 of this work.

I would like to thank the computer science departments staff Level 7 building 11 UTS.

Finally, I would like to express my gratitude and special thanks to the Saudi Arabia Cultural Mission (SACM) in Australia for supporting me all the way from the early days of my masters degree to PhD degree.

Mohammed Ikram

Sydney, Australia, 2019.

# List of Publications

The following is a list of my research papers during my PhD study.

### Journal Papers

J-1. **Mohammed Abdulaziz Ikram**, Nabin Sharma and Farookh Khadeer Hussain, "Intelligent Service Broker approach for Ranking, Evaluation and Selection of Cloud SaaS".

### Conference Papers

C-1. **Mohammed Abdulaziz Ikram**, Farookh Khadeer Hussain: Software as a Service (SaaS) Service Selection Based on Measuring the Shortest Distance to the Consumer's Preferences. EIDWT 2018: pp.403-415

C-2. **Mohammed Abdulaziz Ikram**, Nabin Sharma, Muhammad Raza, Farookh Khadeer Hussain:Dynamic Ranking System of Cloud SaaS Based on Consumer Preferences - Find SaaS M2NFCP. AINA 2019: pp.1000-1010

c-3. **Mohammed Abdulaziz Ikram**, Nabin Sharma, Omar Hussain and Farookh Khadeer Hussain, "Towards Linguistic-based Evaluation System of Cloud Software as a Service (SaaS) Provider".

C-4. **Mohammed Abdulaziz Ikram**, Nabin Sharma, Farookh Khadeer Hussain:The Non-Functional Cloud Software as a Service (SaaS) classification based on Quality of Service (QoS) and Quality of Experience (QoE).

# Contents

# List of Figures

# List of Tables

# Abbreviation

AHP - Analytic Hierarchy Process

AV - Availability

CC - Cloud Computing

CRM - Customer Relationship Management

DMS - Decision Maker System

ELECTRE - ELimination Et Choix Traduisant la REalit

ERP - Enterprise Resource Planning

FAM - Fuzzy Associative Matrix

GA - Genetic Algorithm

HR - Human Resources

IaaS - Infrastructure as a Service

mAP - Mean Average Precision

MCDM - Multi-Criteria Decision Making

MIX - Mixed Integer Programming

MODM - Multi Objective Decision Making

MOO - Multi Objective Optimization

nDCG - Normalized Discounted Cumulative Gain

NF - Non-Functional

OU - Optimizer Unit

PaaS - Platform as a Service

PR - Price

PSO - Particle Swarm Optimization

RbSR -Reputation-based Service Reviewers

RS - Ranking System

RT - Response Time

RV - Service Reviewers

SaaS - Software as a Service

SAW - Simple Additive Weighting

SOA - Service-Oriented Architecture

SR - Service Rating

SRR - Service Registry Repository

TH - Throughput

TOPSIS - Technique for Order of Preference by Similarity to Ideal Solution