UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Supporting consumer decisions in cloud computing using trust model

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Muhammad Raza declare that this thesis, is submitted in fulfilment of the requirements for the award of PhD, in the School of Computer Science, Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced 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.

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List of Publications

Journal Articles

1. Raza, M., Hussain, F. K., Hussain, O. K., Zhao, M., & Rehman, Z. u. (2019). A comparative analysis of machine learning models for quality pillar assessment of SaaS services by multi-class text classification of users' reviews. Future Generation Computer Systems, 101, 341-371. (***JCR(Q1), Impact Factor (6.125)***)
2. Raza, M., Hussain, F.K., Hussain, O.K. et al. Imputing sentiment intensity for SaaS service quality aspects using T-nearest neighbors with correlation-weighted Euclidean distance. Knowl Inf Syst 63, 2541–2584 (2021). ***JCR(Q2), Impact Factor (2.936)***)

Table of Contents

List of Figures

List of Tables

Glossary of terms

In this section, I present the key definition of the terms used in this chapter and rest of the thesis.

Cloud computing

Cloud computing is a computing paradigm in which the computer resources are virtualized and are accessed over the internet as web services.

Cloud service

A virtualized computing resource that is accessed over the internet.

Cloud service provider

An entity that owns and provides cloud services.

Cloud service customer

An entity that uses cloud services. The terms cloud service customers, cloud service users and cloud service consumers are used interchangeably in this thesis.

Cloud services delivery model

The way a cloud service is delivered to the cloud customer i.e., as a virtualized infrastructure (Infrastructure as a Service), as a virtualized application development and deployment platform (Platform as a Service) and as a virtualized software (software as a Service).

Software as a Service

A shared virtualized software that is used by the cloud service customers over the internet.

Cloud service selection

The process of choosing cloud services from the available services.

Well-architected framework

Frameworks proposed by Amazon web services (AWS, 2018) and Microsoft Azure (Azure, 2018) which are based on architectural best practices for cloud application design and operations.

Service factors

The key factors for the optimal design and operations of cloud applications and services. The terms service aspect, service factor, trust factor, software quality pillars and pillars of well-architected framework are used interchangeably in this thesis.

Customer review

Textual feedback by a cloud service customer based on previous experience.

Label

Representation of a textual data into a given category.

Data pre-processing

The process of manipulating a textual data into an acceptable format as input for the next stage.

Ensemble model

A technical combination of two or more machine learning models.

Sentiment intensity

The strength of cloud service customer's opinion.

Trust

The belief in an entity.

Trust model

A formal representation of the belief in an entity. In this thesis, it is the belief in a Software as a Service.

Trustworthiness level

The linguistic representation of the level of belief in a Software as a Service.

Trust value

A numerical representation of the level of belief in a Software as a Service.

Missing data

An unobserved data during the data collection stage.

Imputation

The process of inserting a new value for an unobserved value of a given variable.

Inference

To deduce a missing observation by learning from the existing evidence following a reasoning technique.

Threshold

A numerical acceptance level for a given measurement.

Time spot

The instance of time for which an observation or forecast is referred to.

Time slot

An interval of time for which a set of observations or forecasts are divided.

Time stamp

A date or time label associated to a time spot.

Forecasting

The process of predicting a value for a given time spot in the future.

Abstract

In recent years, cloud computing has gained much attention in research. Compared to its predecessor computing paradigms, cloud computing is more complex in its infrastructure and the nature of services it provides to its customers. Customers are reluctant to adopt cloud computing because of the ongoing issues such as data security, privacy and highly abstract nature of the cloud services. There is a need to facilitate consumer decisions when it comes to cloud services selection. Trust can play an important role in bringing the consumers closer to cloud computing as it has been successfully implemented in several domains. The complex nature of cloud services specially, the Software as a Service (SaaS), brings new challenges for trust modelling compared to the trust models in other domains. In the existing literature, there are a number of approaches proposed to model the trust in cloud services. However, the majority of existing research is focused on establishing the concept of trust and to assess the willingness of cloud service providers. Trust is multi-faceted, dynamic and is based on multiple factors. Besides cloud service providers willingness, the existing literature does not consider the SaaS architectures and their dependencies in their trust models. Besides that, computing trust in SaaS requires the information regarding all the trust factors. There is no approach in the existing literature to address the issue of missing information in the trust factors. Furthermore, the existing literature has not focused on forecasting the trust factors for the future time spots which is important in boosting customers confidence in the adoption of SaaS. The computation of trust in SaaS must adopt to time and should be reliable. The existing trust models for cloud services do not provide comprehensive solution that captures both dynamicity and reliability of trust factors.

Based on the shortcoming mentioned above, in this thesis I propose and develop a comprehensive trust management framework for SaaS. The proposed framework identifies the key trust factors from SaaS architectural best practices. Each component of the framework is designed to address the issues faced by trust models for SaaS. In the first component of the framework, an ensemble machine learning approach automatically categorizes and extracts the trust factors from SaaS customer reviews. An intelligent Threshold-based Nearest Neighbour (T-NN) method is proposed to impute the missing customer sentiments in SaaS service factors. The third component of the framework is designed to forecast the values of the SaaS service

factors. The forecast model is designed through a comprehensive study of the traditional and latest forecasting approaches. Finally, the last component of the framework, models the trust using an intelligent and dynamically weighted fuzzy trust model. Each component of the proposed trust management framework is validated against several well-known approaches during experiments.

This thesis will help and facilitate cloud services consumers in their decisions before utilizing cloud services and also the SaaS providers to improve different aspects of their offered services.