

**TRUSTED CLOUD COMPUTING FRAMEWORK IN CRITICAL  
INDUSTRIAL APPLICATION**

**MERVAT ADIB BAMIAH**

**UNIVERSITI TEKNOLOGI MALAYSIA**

TRUSTED CLOUD COMPUTING FRAMEWORK IN CRITICAL INDUSTRIAL  
APPLICATION

MERVAT ADIB BAMIAH

A thesis submitted in fulfilment of the  
requirements for the award of the degree of  
Doctor of Software Engineering

Advanced Informatics School  
Universiti Teknologi Malaysia

JANUARY 2015

*This research is dedicated to my beloved family and  
Dr. Mohammad Imran Bamiah.*

## **ACKNOWLEDGEMENT**

I would like to express my utmost gratitude to ALLAH (SWT), the God Almighty, for granting me health, knowledge, strength, ability, and patience to accomplish this research. I wish to express my sincere appreciation to my main supervisor, Dr. Suriyati Chuprat for her continuous support and valuable feedbacks that enabled me to achieve the research milestones within the required time-frame. I am thankful also to my external research industry supervisor Dr. Jamalul-lail Ab Manan for his continuous support and valuable feedbacks in reviewing, improving and evaluating my research. I am extremely thankful to Dr. Mohammad Imran Bamiah for his financial and caring support. Also I am grateful to every member of my family who stood by me with kind and love during the PhD journey.

## ABSTRACT

Cloud computing facilitates instant online unlimited access to data and computing resources, ubiquitously and pervasively through its various service delivery and deployment models. Despite the significant advantages of cloud computing, still there are concerns regarding Security, Privacy and Trust (SPT) that resulted from consumers' loss of control over their confidential data since they outsource it to cloud with no knowledge of storage location or who is accessing and maintaining it. This raises the risks of insider and outsider threats besides the data breach and misuse. A Trusted Cloud Computing Framework (TCCF) is designed to overcome these SPT concerns. TCCF proposes the use of Trusted Computing Group (TCG) technologies including, Trusted Platform Module (TPM), Virtual Trusted Platform Module (VTPM), Self-Encrypting Drives (SEDs), Trusted Network Connect (TNC) and Trusted Software Stack (TSS) to initiate a trusted cloud computing platform. In addition, a Multi-Factor Authentication Single Sign on Role Base Access Control (MFA-SSO-RBAC) prototype was developed using a strict security controls. Furthermore, an additional context for cloud Service Level Agreement (SLA) was proposed to support the framework and to ensure the trustworthiness of the cloud computing services to be adopted in critical information industries specifically healthcare sector. TCCF was evaluated by developing a prototype, comprehensive comparison with previous work, compliance with standards and a survey from cloud computing, healthcare and IT security experts. Feedbacks of experts were satisfactory and they agreed with 94% on the overall security techniques used to secure the TCCF three layers. The evaluation proves that TCCF assists in optimizing the trust on cloud computing to be adopted in healthcare sector for best practices.

## ABSTRAK

Pengkomputeran awan memudahkan akses dalam talian segera tanpa had terhadap data dan sumber pengkomputeran secara merata dan merebak melalui pelbagai tawaran penyampaian perkhidmatan dan model penempatan. Walaupun pengkomputeran awan mempunyai kelebihan yang signifikan, masih terdapat beberapa isu berkaitan Keselamatan, Kerahsiaan dan Kepercayaan (SPT) disebabkan oleh kehilangan kawalan terhadap data sulit pengguna itu sendiri. Keadaan ini berlaku kerana mereka menggunakan khidmat penyumberan luar awan tanpa mengetahui sebarang maklumat tentang lokasi sebenar data dan juga siapa yang mencapai dan menguruskan maklumat tersebut. Ini akan meningkatkan risiko ancaman dalaman dan luaran selain kebocoran dan penyalahgunaan data. Rangka Kerja Pengkomputeran Awan Dipercayai (TCCF) direka bentuk untuk mengatasi kebimbangan SPT. TCCF mencadangkan penggunaan Teknologi Pengkomputeran Kumpulan Dipercayai (TCG) termasuk Modul Platform Dipercayai (TPM), Modul Platform Dipercayai Maya (VTPM), Pemacu Penyulitan Diri (SEDs), Rangkaian Sambung Dipercayai (TNC) dan Perisian Timbunan Dipercayai (TSS) untuk memulakan platform pengkomputeran awan yang dipercayai. Di samping itu, prototaip Pengesahan Tandatangan Tunggal Pelbagai-Faktor pada Kawalan Akses Berasaskan Peranan (MFA-SSO-RBAC) dibangunkan menggunakan kawalan keselamatan yang ketat. Seterusnya, konteks tambalan untuk Perjanjian Tahap Perkhidmatan (SLA) awan dicadangkan untuk menyokong rangka kerja dan memastikan kebolehpercayaan perkhidmatan awan yang akan diterima pakai dalam industri maklumat kritikal khususnya sektor penjagaan kesihatan. TCCF telah dinilai dengan membangunkan prototaip, perbandingan komprehensif dengan kerja sebelumnya, kepatuhan kepada standard dan kaji selidik daripada pakar-pakar pengkomputeran awan, penjagaan kesihatan, dan keselamatan IT. Maklum balas daripada pakar adalah memuaskan hati dan setuju secara purata 94% daripada keseluruhan teknik keselamatan yang digunakan untuk memelihara tiga lapisan TCCF. Penilaian tersebut membuktikan bahawa TCCF dapat membantu meningkatkan keyakinan terhadap amalan terbaik dalam pengkomputeran awan untuk digunakan dalam sektor penjagaan kesihatan.