



Faculty of Information and Communication Technology

**INFORMATION SECURITY BEHAVIOUR ASSESSMENT IN
SOFTWARE-AS-A-SERVICE CLOUD ENVIRONMENT**

Hanifah binti Abdul Hamid

Doctor of Philosophy

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SOFTWARE-AS-A-SERVICE CLOUD ENVIRONMENT**

HANIFAH BINTI ABDUL HAMID

**A thesis submitted
in fulfillment of the requirements for the degree of Doctor of Philosophy**

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2018


DECLARATION

I declare that this thesis entitled "Information Security Behaviour Assessment in Software-as-a-Service Cloud Environment" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

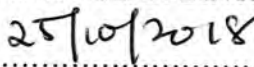
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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in term of scope and quality for the award of Doctor of Philosophy.

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Date : 

DEDICATION

To my beloved husband, parents and children

ABSTRACT

This research aims at assessing the information security behaviour in Software as a Service (SaaS) cloud computing environment. Organisations are still struggling with information security breaches despite various technical protections to secure SaaS applications. This is due to the fact that human behaviour is the weakest link of the security chain. Security compromise causes substantial financial and nonfinancial losses to the organisations which jeopardise organisations' reputation. Technical protection alone is seemed insufficient to ensure information safety. Therefore, this research takes it from the socio-organisational perspective to strengthen information security. Many socio-organisational factors influence employees' security behaviour in the organisation which gives impact to SaaS cloud adoption. Addressing these factors are significant to help successfully create a healthy security culture in the organisation. Nevertheless, human behaviour is subjective in nature. Their behaviour depends upon the way they think feel and act towards security issues which needs an in depth understanding towards their security behaviour. Hence, adapting the sequential exploratory mixed-method approach, through the theoretical lens of social cognitive theory, organisational culture theory as well as security control from extended deterrence theory, this study develops an information security behaviour model and validates the socio-organisational aspects of security behaviour. There were 396 useful data gathered from the survey. SPSS 20 and PLS-SEM software were utilised for descriptive and exploratory factor analysis respectively. The survey results indicate that the security control management, personal values and behaviour were salient factors towards formation of good security behaviour. This research subsequently conducted a case study using the proposed model at one information technology department in a public university. The survey obtained 90 useful data. The case study revealed that organisational security culture, personal values as well as behaviour have significant influence towards information security behaviour. There were slight differences in the quantitative results to which the follow-up interview with three informants supported the findings from the case study. It can be concluded that personal values and behaviour elements are the most significant factors which influence information security behaviour of employees working in SaaS cloud environment. However, the organisation culture and security control management factors are observed to be contextually dependent as these factors depend on how the organisation is run by the respective top management. This study contributes both theoretically and practically. The information security behaviour's body of knowledge is built up through conceptual model testing and accentuating new propositions. The information security behaviour model was developed upon the integration of social cognitive theory, Wallach Organisational Culture Model as well as security control management from extended deterrence theory, and validated through a survey and a case study. The result helps the researcher to have better insight of employees' security behaviour in SaaS cloud environment in Malaysia generally and at the studied IT department specifically. The developed model, new accentuated propositions and other recommendations in this research may help other researchers to embark on related studies in the future.

ABSTRAK

Kajian ini bertujuan untuk menilai tingkah laku keselamatan maklumat di dalam konteks persekitaran perkomputeran awan Dewasa ini organisasi masih lagi berhadapan dengan cabaran kebocoran maklumat walaupun mempunyai pelbagai perlindungan teknikal bagi memastikan keselamatan aplikasi SaaS yang digunakan. Ini kerana tingkah laku pekerja-pekerja itu sendiri yang merupakan titik paling lemah dalam rantai keselamatan maklumat. Keselamatan maklumat yang terjejas menyebabkan kerugian kewangan dan bukan kewangan yang besar kepada organisasi. Perlindungan teknikal sahaja seperti tidak mencukupi untuk memastikan keselamatan maklumat. Oleh itu, kajian ini menggunakan perspektif sosio-organisasi untuk memperkukuhkan keselamatan maklumat. Faktor sosio-organisasi banyak mempengaruhi kelakuan keselamatan pekerja dalam organisasi yang juga memberi kesan kepada perkembangan penggunaan perkomputeran awan. Menangani faktor kritikal ini adalah penting untuk membantu mewujudkan budaya keselamatan yang sihat dalam organisasi. Walau bagaimanapun, perlakuan manusia adalah bersifat subjektif bergantung kepada cara mereka berfikir, merasa dan bertindak terhadap isu-isu keselamatan yang memerlukan pemahaman yang mendalam terhadap tingkah-laku keselamatan. Melalui pendekatan penerokaan berjujukan kaedah bercampur, berdasarkan kanta teori kognitif sosial, teori budaya organisasi Wallach serta pengurusan kawalan keselamatan dari teori pencegahan lanjutan, kajian ini membangunkan model dan mengesahkan aspek-aspek sosio-organisasi tingkah laku keselamatan. Terdapat 396 data berguna yang dikumpul dari hasil soal-selidik ini. SPSS 20 dan perisian PLS-SEM telah digunakan untuk analisis faktor penerokaan dan deskriptif masing-masing. Hasil kajian soal-selidik menunjukkan bahawa pengurusan kawalan keselamatan, nilai-nilai peribadi dan tingkah laku peribadi adalah faktor ke arah pembentukan tingkah laku keselamatan yang baik. Kajian ini kemudiannya dilanjutkan ke satu kajian kes dengan menggunakan model yang dibentuk di sebuah jabatan teknologi maklumat di universiti awam. Kaji selidik itu memperolehi 90 data. Kajian kes ini mendedahkan bahawa budaya keselamatan organisasi, nilai-nilai peribadi serta tingkah laku mempunyai pengaruh yang signifikan ke arah tingkah laku keselamatan maklumat. Temu bual sorotan bersama tiga orang pekerja atasan di jabatan berkenaan menyokong dapatan kuantitatif kajian kes. Maka dapatlah disimpulkan bahawa nilai-nilai peribadi dan elemen-elemen tingkah laku adalah faktor paling penting yang mempengaruhi tingkah-laku keselamatan maklumat pekerja-pekerja yang bekerja dalam persekitaran awan SaaS. Walau bagaimanapun, budaya organisasi dan pengurusan kawalan keselamatan adalah faktor-faktor yang berasaskan konteks kajian kerana faktor-faktor ini bergantung kepada bagaimana organisasi dikendalikan oleh pengurusan tertinggi masing-masing. Kajian ini menyumbang kepada pengetahuan di bidang sistem maklumat melalui pembangunan model integrasi tingkah laku keselamatan yang disahkan melalui kaji selidik dan kajian kes dan saranan gagasan-gagasan baru. Hasilnya membantu penyelidik untuk lebih memahami tingkah laku keselamatan dalam konteks persekitaran perkomputeran awan SaaS di Malaysia amnya dan di jabatan yang dikaji khususnya. Model yang dibangunkan dan gagasan-gagasan baru yang diutarakan dalam penyelidikan ini dapat membantu penyelidik lain untuk memulakan kajian yang berkaitan pada masa hadapan.

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TABLE OF CONTENTS

	PAGE
DECLARATION	
APPROVAL	
DEDICATION	
ABSTRACT	i
ABSTRAK	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	x
LIST OF APPENDICES	xii
LIST OF ABBREVIATIONS	xiii
LIST OF PUBLICATIONS	xvi
CHAPTER	
1. INTRODUCTION	1
1.1 Introduction	1
1.2 Statement of the Purpose	3
1.3 Research Background	
1.3.1 Security Challenges in Cloud Environment	6
1.3.2 Security Risks and Threats and Attack in the Cloud Environment	8
1.3.3 Security Incidents in Malaysia	8
1.4 Problem Statement	10
1.5 Research Questions	11
1.6 Research Objectives	12
1.7 Research Scope	12
1.8 Research Significance	13
1.9 Definitions of Operational Terms	15
1.10 Organisation of Thesis	17
2. LITERATURE REVIEW	20
2.1 Introduction	20
2.2 Cloud Computing Environment	20
2.2.1 Definition	21
2.2.2 Cloud Essential Characteristics	22
2.2.3 Cloud Computing Service Models	23
2.2.4 Cloud Deployment Models	29
2.2.5 Cloud Adoption	30
2.2.6 Global Cloud Environment	31
2.2.7 Cloud Environment in Malaysian Context	33
2.2.8 Malaysian Cloud Readiness	35
2.3 Human and Information Security Challenges in the Cloud Environment	37
2.4 Information Safety and Security Behaviour	38
2.5 Theoretical Lens of ISB	41
2.5.1 Behavioural Theories	42
2.5.2 Organisational Culture Theories	47
2.6 ISB and Cultural Values	50
2.7 Existing Information Security Culture Work	52

2.8	Existing Information Security Culture Work in Malaysia	58
2.9	Factors Influencing Information Security Behaviour	60
2.9.1	Behavioural Factor	60
2.9.2	Environment Factor	62
2.9.3	Personal Values Factor	64
2.9.4	Organisation Culture Factor	66
2.9.5	Security Control Management Factor	68
2.10	Conceptual Framework	73
2.11	Summary	75
3.	METHODOLOGY	76
3.1	Introduction	76
3.2	Research Paradigm	77
3.2.1	Ontological Belief	77
3.2.2	Epistemological Belief	78
3.3	Research Approach	79
3.3.1	Qualitative Research	80
3.3.2	Quantitative Research	80
3.3.3	Mixed Method Research	80
3.4	Assessment Method of Information Security Behaviour Studies	82
3.5	Research Design	84
3.6	Hypotheses Development	85
3.7	Instrument Development	89
3.7.1	Constructs Operationalisation	89
3.7.2	Pilot Study	89
3.7.3	Final Construct Operationalisation	93
3.8	Research Sampling	100
3.8.1	Define Target Population	101
3.8.2	Identify Sampling Frame	102
3.8.3	Select Sampling Method	102
3.8.4	Determine Sample Size	105
3.8.5	Collect Data from Sample	108
3.9	Research Stage and Data Collection Method	108
3.9.1	Survey	108
3.9.2	Case Study	109
3.9.3	Interview	110
3.10	Data Analysis Methodology	113
3.10.1	Data Preparation and Screening	113
3.10.2	Data Analysis Method	115
3.11	Summary	130
4.	DATA ANALYSIS AND RESULTS OF SURVEY	131
4.1	Introduction	131
4.2	Response Rate	132
4.3	Data Editing and Coding	132
4.4	Data Cleaning	133
4.5	Data Distribution and Normality	133
4.6	Descriptive Analysis of Survey	134
4.7	Exploratory Factor Analysis (EFA) of Survey	136
4.8	Analysis of the Measurement Model of Survey	141

4.8.1	Formative Scales	142
4.8.2	Reflective Scales	147
4.9	Assessment of the ISB Structural Model of Survey	156
4.9.1	Collinearity Assessment	157
4.9.2	Structural Model Path Coefficients	158
4.9.2	Coefficient of Determination (R^2 Value)	164
4.10	Descriptive Analysis of Case Study	167
4.11	Analysis of the Measurement Model of the Case Study	171
4.11.1	Formative Scales Measurement Model	171
4.11.2	Reflective Scales Measurement Model	175
4.12	Analysis of the Structural Model of the Case Study	178
4.13	Qualitative Analysis of the Case Study	186
4.13.1	Organisation Culture	187
4.13.2	Security Control Management	189
4.13.3	Personal Values	195
4.13.4	Environment	196
4.13.5	Behaviour	197
4.13.6	Other Findings	198
4.14	Summary	205
5.	DISCUSSION	206
5.1	Introduction	206
5.2	Discussion of Research Findings	207
5.2.1	Personal Values and ISB	207
5.2.2	Behaviour and ISB	209
5.2.3	Environment and ISB	211
5.2.4	Organisation Culture and ISB	213
5.2.5	Security Control Management and ISB	217
5.3	The Developed ISB Model	222
5.4	Highlights of New Propositions	223
5.5	Secured Information Systems	225
5.6	Other Point of Discussions	226
5.7	Summary	228
6.	CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH	229
6.1	Introduction	229
6.2	Research at a Glance	229
6.3	Research Contributions	234
6.3.1	Theoretical Contributions	234
6.3.2	Practical Contributions	241
6.4	Research Limitation	246
6.5	Conclusion and Recommendations for Future Research	246
	REFERENCES	249
	APPENDICES	287

LIST OF TABLES

TABLE	TITLE	PAGE
1.1	Challenges of Cloud Adoption in Malaysia	8
1.2	Reported Incidents Based on General Classification Statistics January-April 2015	9
1.3	Reported Incidents Based on General Classification Statistics Jan-June 2017	10
2.1	MyCERT Spam Email Statistics as of Jan – July 2017	24
2.2	Leading Social Networks Worldwide as of September 2016	27
2.3	Forecast Number of Personal Cloud Storage Users Worldwide from 2014 to 2020	28
2.4	Cloud Readiness Index 2014	36
2.5	Cloud Readiness Index 2018 – Malaysia’s Scores and Rankings	36
2.6	Information Security Culture Studies Based on Aims Classification	53
2.7	Factors Influencing Security Behaviour	57
2.8	Selected Factors Influencing Information Security Behaviour	72
3.1	Research Paradigm	78
3.2	Summary of Research Approach	82
3.3	Research Design	84
3.4	Profile of Respondents of Pilot Study	91

3.5	Followed-up Interview Participants' Profile Summary	92
3.6	Analysis of Items	93
3.7	Operationalisation of Personal Values Factor	95
3.8	Operationalisation of Behaviour Factor	96
3.9	Operationalisation of Environment Factor	97
3.10	Operationalisation of Organisation Culture Factor	98
3.11	Operationalisation of Security Control Management Factor	99
3.12	Operationalisation of Overall ISB	101
3.13	Summary of the Instruments Used for Each Phase of the Research	112
3.14	Research Nature vs. Analysis Techniques	118
3.15	Types of Qualitative Analysis	120
3.16	Interview Questions	126
4.1	Demographics Profiles of Respondents	134
4.2	The Exposure of Respondents on SaaS Applications	135
4.3	EFA –ENV	137
4.4	EFA – BHV	138
4.5	EFA – Personal Values	139
4.6	EFA for SCM	140
4.7	Redundancy Analysis of Formative Measurement Indicators	143
4.8	Variance Inflation Factor Results	144
4.9	Bootstrapping Result for Formative Indicators	145
4.10	Fornell-Larker Criterion	151
4.11	Result Summary for Reflective Measurement Models	153
4.12	Collinearity Assessment	157
4.13	Results for the Path Coefficient of the ISB Structural Model	160

4.14	Significance Testing Results of the Total Effects	162
4.15	R ² of the ISB Model	164
4.16	Convergent Validity	167
4.17	Collinearity Assessment	168
4.18	The Formative Measurement Analysis	174
4.19	Fornell-Larcker Assessment before the Dismissal of BF16	176
4.20	Final Results of Fornell-Larcker Criterion	176
4.21	Summary of Reflective Measurement Model Evaluation	177
4.22	Collinearity Assessment Result	179
4.23	Significance Testing Results of the Structural Model Path coefficients at GIC	180
4.24	Significance Testing Results of the Total Effects at GIC	182
4.25	Coefficient of Determination for GIC	183
4.26	Summary of the Informants	186
5.1	Comparison of Hypotheses between Survey and Case Study - PV	207
5.2	Comparison of Hypotheses between Survey and Case Study - BHV	209
5.3	Comparison of Hypotheses between Survey and Case Study - ENV	211
5.4	Comparison of Hypotheses between Survey and Case Study – OC	213
5.5	Comparison of Hypotheses between Survey and Case Study – SCM	218
6.1	The Summary of Research Objectives, Research Questions and Deliverables	230

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Security Challenges in Cloud Adoption	7
1.2	Thesis Structure	19
2.1	Schematic Definition of Cloud Computing	21
2.2	Cloud's Essential Characteristics, Service Models and Deployment Models	30
2.3	Cloud Adoption Research in Malaysia Based on Domains	34
2.4	Levels of Countermeasure from Human and Technical Perspective	39
2.5	Social Cognitive Theory	43
2.6	Deterrence Theory	47
2.7	Conceptual Framework	74
3.1	SaaS ISB Proposed Model	88
3.2	Sampling Procedure	102
3.3	Sample Size Recommended by Roasoft®	108
3.4	Content Analysis Phases – Preparation, Organising, and Reporting	121
3.5	Research Framework	129
4.1	ISB Measurement Model	155
4.2	Structural Model Assessment Procedure	156
4.3	Structural Model of SaaS ISB	166
4.4	SaaS ISB Structural Model for GIC	185

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Organisational Culture Model, Values and Definition	284
B	Framework and Method Used in ISC Research	289
C	Method Used in ISC Research	294
D	Normality Test Using Kalmogorov Smirnov	296
E	Questionnaire	301
F	Probability and Non-Probability Sampling Design	315

LIST OF ABBREVIATIONS

ACCA	-	Asian Cloud Computing Association
ARPANET	-	Advanced Research Projects Agency Network
AVE	-	Average Variance Extracted
BHV	-	Behaviour
BRCTC	-	Bureaucratic
CB-SEM	-	Covariance Based Structured Equation Modelling
CCTV	-	Closed-circuit Television
CIA	-	Confidentiality Integrity Availability
COBIT	-	Control Objectives for Information and Related Technologies
COCO	-	Confidential Consortium
DT	-	Deterrence Theory
EDT	-	Extended Deterrence Theory
EFA	-	Exploratory Factor Analysis
ENV	-	Environment
GSA	-	General Service Administration
HHS	-	Department of Health and Human Services
IaaS	-	Infrastructure as a Service
INVTV	-	Innovative
IoT	-	Internet of Things

IPCA	-	Information Protection Culture Assessment
IS	-	Information System
ISC	-	Information Security Culture
ISB	-	Information Security Behaviour
ISO	-	International Organisation for Standardisation
IT	-	Information Technology
ITIF	-	Information Technology and Innovation Foundation
IQR	-	Inter Quartile Range
KMO	-	Kaiser-Meyer-Olkin
MAMPU	-	Malaysian Administrative Modernization and Planning Unit
MDeC	-	Malaysian Digital Economy Corporation
MMCI	-	MSC Malaysia Cloud Initiative
MSC	-	Multimedia Super Corridor
MyCERT	-	Malaysian Certified Emergency Response Team
NASA	-	National Aeronautics and Space Administration
NGO	-	Non-governmental Organisation
NIST	-	National Institute of Science and Technology
OC	-	Organisation Culture
PaaS	-	Platform as a Service
PLS-SEM	-	Partial Least Square Structured Equation Modelling
PMT	-	Protection Motivation Theory
PRCTC	-	Practice
PSM	-	Physical Security Monitoring
PV	-	Personal Values
RAM	-	Risk Analysis and Management

RFID	-	Radio-Frequency Identification
SaaS	-	Software as a Service
SCM	-	Security Control Management
SCT	-	Social Cognitive Theory
SESE	-	Skills Experience and Self-Efficacy
SETA	-	Security Education Training and Awareness
SME	-	Small and Medium Enterprise
SNS	-	Social Network Service
SPP	-	Security Policies and Procedures
SPRTV	-	Supportive
SPSS	-	Statistical Package for the Social Sciences
SSO	-	Single Sign On
TPB	-	Theory of Planned Behaviour
TRA	-	Theory of Reasoned Action
VM	-	Virtual Machine
WOC	-	Wallach Organisation Culture
WOCI	-	Wallach Organisation Culture Index

LIST OF PUBLICATIONS

Abdul-Hamid, H., Yusof, M.M., Mohd Dali, N.R.S. 2017. Security Compliance Behaviour of SaaS Cloud Users: A Pilot Study. *Journal of Engineering and Applied Sciences*, 15(15), pp. 4150-4155.

Abdul Hamid, H., Yusof, M. M. 2016. Conceptualizing Global Cloud Landscape: A Review of Adoption Issues and Challenges. *Research Journal of Applied Sciences*, 11(6), pp. 333–339.

Abdul Hamid, H., Mohd Yusof, M. 2015. State-of-the-Art of Cloud Computing Adoption in Malaysia: A Review. *Jurnal Teknologi (Sciences and Engineering)*, 77(18), pp. 1–6.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This study focuses on the information security behaviour assessment (ISB) of employees in the context of Software-as-a-Service (SaaS) cloud computing environment.

Organisations in the whole world have been adopting computer-based information systems (IS) to gain business values ever since its introduction in the early 1960s. The strategic IS play a vital role in aligning the business goals of the organisation with the advent of information technology (IT) to achieve its business values as well as to gain competitive advantage. Nevertheless, the rapid development of information technology has revolutionised IS and changed the way business is done in the organisations.

In the current situation, with the advent technology of Internet of Thing (IoT), a more sophisticated technology called cloud computing has emerged to transform the business landscape globally. Whilst cloud computing offers significant advantages to the adopters and users, it also comes with challenges. There is no secret that security has become the main concern and barrier that deter many organisations from adopting cloud computing (Dua, 2014).

Gartner, a renowned IT consulting, highlighted that security, environment and governance are still the main factors affecting cloud adoption (Gartner, 2015) and this notion is in line with the challenges reported by NIST (Mell and Grance, 2009). Bachlechner et al. (2014) confirmed that cloud computing faces challenges in terms of auditing clouds, managing heterogeneity of

services, coordinating involved parties, managing relationship between clients and vendors, localising and migrating data and more importantly, coping with the lack of security awareness.

For instance, security incidents have happened recently which prove this claim. In January 2015, the website of Malaysian Airlines, a government linked company, was hacked by Lizard Squad; an image of a lizard wearing a hat with the caption of “Plane-Not-Found,” was displayed on the website, following the incident of the missing MH370 in 2014. Prior to that, Lizard Squad attacked Sony Play station and Microsoft Xbox Live. Google Malaysia was also hacked and this happened in April 2015 where users were redirected to the hacker site claimed as Bangladeshi Tigermate hacker (Hamzah, 2015). All these incidents negatively influence the decision makers in adopting cloud computing in the organisations. Analysis done in April 2015 by Malaysian Computer Emergency Response Team (MyCERT), a security agency of Cyber security Malaysia, reveals that security incidents happen all the time with spam being the highest vulnerability, followed by fraud, intrusion, cyber harassment, malicious code, intrusion attempt and denial of service.

Computer scientists have come up with various technical solutions to overcome security hindrance. Yet, security incidents still occur over time. Information security in cloud is much challenging than in the traditional IS because cloud is a shared computing environment. Security threats are everywhere, and the risks are higher in the cloud environment. Technical solutions alone are not sufficient to protect the information in cloud environment. Therefore, inculcating ISB as part of the whole security solutions of cloud computing may help boost the level of cloud adoption.

1.2 Statement of the Purpose

This research mainly aims at assessing the information security behaviour of employees in the SaaS cloud environment.

1.3 Research Background

Due to the emerging phenomenon of cloud computing, the researcher has been putting a great deal of interest to investigate the adoption and utilisation of cloud computing among users. Cloud computing is known to have the flexibility of offering the latest dynamic IT services with lower associated costs as asserted by Al-Badi et al.(2017). However, despite its tremendous advantages, it was found that the adoption growth is much slower than anticipated due to security obstacle (Zhang et al., 2017).

Security has become and is nevertheless the major issues of information technology adoption inclusive cloud computing (Rebollo et al., 2015) . The exposure to security threats is more critical and the risks are greater in cloud environment. Various security technical protections have been employed to protect information systems in cloud from risks, threats and vulnerabilities such as cryptography, biometric and firewalls within and beyond the four walls of the organisations. However, security breaches still happen and keep rising over time.

Of all the causes, human is the main vulnerability (Miller et al., 2015) and is the weakest link of security breaches (AlHogail, 2015) inside or outside of the organisation, since any human errors, intentionally or accidentally, can compromise the security protection. The people's characteristics, shared values and norms shape their security behaviour in cloud computing environment thus affecting the safety of the information. A security breaches study reported that the employees and former staff are the main culprits of security incidents, however, current and