UNIVERSITY OF SOUTHAMPTON

FACULTY OF PHYSICAL SCIENCES AND ENGINEERING

Electronics and Computer Science (ECS)

Electronic and Software Systems (ESS)

# A Critical Success Factors Assessment Instrument for Cloud Migration Readiness Status in Saudi Arabian Universities

By

**Abdulrahman Ayad Alharthi**

BSc. MSc.

Thesis for the degree of Doctor of Philosophy in Computer Science

September 2017

*Dedicated To*

*My father,*

*My mother,*

*My wife,*

*My three brothers,*

*My sister*

WITHOUT THEIR SUPPORTS THIS WORK WOULD NOT BE ACCOMPLISHED

UNIVERSITY OF SOUTHAMPTON

# ABSTRACT

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Saudi universities have at their disposal a huge number of low cost IT resources to aid teaching, research and learning. The emergence of cloud computing delivers substantial benefits in the form of rich education content, increased efficiency and agility that can be used to transform higher education in Saudi universities. By migrating to cloud services, Saudi universities will be moving data and programs from local servers to the internet, thereby providing users with the ability to access and share information at any time from multiple devices. Also, procuring IT resources such as infrastructure, applications, and platforms via the Internet will be cost effective, easy and fast. This will promote innovation in universities, as the main barrier of cost will be removed. However, the migration to cloud-based IT resources is not yet widespread in Saudi universities due to several challenges including security, legal policies and IT personnel skills. Moreover, at present, there is a lack of research and guidance on the significance of the Critical Success Factors (CSFs) to improve the success of cloud migration projects in Saudi university. These CSFs were used to measure the readiness of Saudi universities in terms of their ability, perception and readiness in making their cloud migration more successful. This research proposes a framework of enablers to guide the Saudi Arabian universities to migrate to the cloud paradigm successfully.

In the presented research, a set of key CSFs was identified by synthesising factors from studies concerned with the migration of cloud for higher education in global context and factors identified from previous research investigating the successful implementation of Web Based Learning (WBL) and Enterprise Resource Planning (ERP) on higher education in Saudi Arabia. Based on the literature review, the proposed Success Factor Cloud Migration (SFCM1) framework was then evaluated via expert reviews and a survey conducted by IT specialists working in Saudi universities. The initial CSFs in SFCM1 were updated based on the expert reviews and the results were analysed via the Thematic Analysis approach. Based on the findings at this stage, additional CSFs were added to the framework as suggested by the experts. Subsequently, in order to confirm the reviewed CSFs, additional

investigation via a structured online questionnaire was conducted and the outcome was analysed via one-sample t-test with the data integrity analysed via Cronbach's alpha. The outcome indicated that most CSFs were statistically significant, apart from, the Physical Location CSF.

Subsequently, based on the confirmed SFCM2 framework, a cloud migration readiness assessment instrument (CMRA) was developed using Goal Question Metrics (GQM) approach. The scoring scales of the CMRA instrument were adapted from the COBIT5 Process Assessment Model (PAM). The practicality of CMRA instrument was evaluated by three case studies conducted in Saudi universities. The instrument was used to assess the readiness status of the Saudi universities that already planned to migrate to the cloud. Afterwards, the usefulness and practicality of the CMRA were evaluated through an evaluation questionnaire and interviews with seniors working in IT deanships in Saudi universities.

The contributions of this research are first that it developed a SFCM2 framework within the context of Saudi Arabian universities. Secondly, the framework was extended to an instrument (CMRA) to measure the readiness status of a particular Saudi university.

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# Declaration of Authorship

I, Abdulrahman Alharthi, declare that this thesis entitled 'A Critical Success Factors' Assessment Instrument for Cloud Migration Readiness Status in Saudi Arabian Universities' and the work presented in it are my own and have been generated by me as the result of my own original research. I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Parts of this work have been published as:

- Alharthi A., Yahya F., Walters R. and Wills G. (2015). An Overview of Cloud Services Adoption Challenges in Higher Education Institutions. In *Proceedings of the 2nd International Workshop on Emerging Software as a Service and Analytics*, ISBN 978-989-758-110-6, pages 102-109. DOI: 10.5220/0005529701020109.
- Alharthi A., Walters R. and Wills G. (2016). A Framework for cloud migration in Saudi Arabia Higher Education. Poster session presented at: 9th Saudi Student Conference; 2016 February 13-14; Birmingham, UK.
- Alharthi, A., Alassafi, M.O., Walters, R.J. and Wills, G.B., 2016, October. Towards a framework to enable the migration process to educational clouds in Saudi higher education. In Information Society (i-Society), 2016 International Conference on (pp. 73-76). IEEE.
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Signed:……

Date: ……..……..

# Acknowledgements

All thanks to Almighty Allah for the help, favours, mercies and blessings he gained me, which have enabled this work to be accomplished.

I would like to express my sincere gratitude and appreciation to my supervisor, Dr Gary Wills, for his invaluable guidance, motivation, patience and endless encouragement to complete this work, particularly in times of hardship. I am also very grateful to my supervisor, Dr Robert J Walters, for his invaluable comments, precious feedback, prompt response to most of my inquiries, ultimate support and immense knowledge. Likewise, my supervisors, I would acknowledge the intellectual atmosphere and equipment provided by the Electronics and Computer Science Department at University of Southampton during my study. I also wish to extend my gratitude to the universities and individuals who have participated in and organised the data collection interviews during this study. There are too many to name, but I especially thank Dr Abdulrahman Alqhtani, Dr Rajab Alsayegh and Dr Omar Almutiry for their endless support in the completion of my PhD.

Uncountable appreciations and gratitude go to my mother, father, brothers and my sister for their inspiration, encouragement and motivation to attain my goal. I am grateful to my mother for her encouragement and prayers during my PhD trip. I also would like to thank my father in law and mother in law for their unforgettable help and support. My sincere thanks also go to my wife, I cannot find suitable words to write or say about my genuine gratitude to my wife for her assistance, love, immense patience and sacrifice of her social life in coming with me to the UK and providing moral support throughout the PhD study.

Last but not least, my sincere thanks also go to my friends: Abu-Talha, Hani Alsayegh, Rami Almalki, Khalid Almodaraa, Saud Aljlaod and Mohammed Alharthi (Abu-Sarah) for their prayers and encouragements. Sincere gratitude is also conveyed to my friends and research colleagues in the ESS department at the University of Southampton, especially Abdullah Alzahrani, Ahmed Alenzi and Madini Alassafi, for their guidance, collaboration in scientific publications and moral support during calamities, making me proud of their friendship.

I sincerely acknowledge the awards of the University of Jeddah scholarship and the Saudi Arabian Cultural Bureau in London (SACB) for allowing the research to be funded and undertaken.

# Glossary of Terms

**CSFs** – Critical Success Factors

**RCs** – Readiness Criteria

**PQs** – Measuring Processes questions

**SLA** – Service Level Agreement

**WBL** – Web based learning

**LMS** – Learning Management Systems

**KSA** – Kingdom of Saudi Arabia

**RE** – Reliability readiness criterion

**SE** – Security readiness criterion

**IN** – Interoperability readiness criterion

**SL** – Service Level Agreement readiness criterion

**MP** – Migration Planning readiness criterion

**CR** – Compliance with Regulations readiness criterion

**ICT** – Information and Communication Technologies

**IT –** Information Technology

**GQM** – Goal Question Metrics Approach

**AHP** – Analytical Hierarchy Process

**NIST** – National Institute of Standards and Technology

**SFCM1** – initial Success Factors for Cloud Migration Version 1: This is the initial solution framework that encompasses the Success Factors that been extracted from the literature review.

**SFCM2** – Confirmed Success Factors for Cloud Migration Version 2: This is the confirmed version of the SFCM framework.

**CMRA** – Cloud Migration Readiness Assessment Instrument

# Chapter 1

# Introduction

Cloud computing is a term used for the Internet-based distributed computing service launched in late 2006. The services provide on-demand computing power that comes with less implementation time, low maintenance resources, lesser staffing overhead and hence lower costs. Due to its immensely promising offers, cloud computing is a dominant research and exploration subject with a market expected to grow exponentially with the rapid growth of the technology demand and the required infrastructure (Yang and Tate, 2012).

Cloud computing offers a wide range of benefits to the existing, global computing infrastructure. Due to a centralised concept, it provides an on-demand and scalable pool of IT resources in a 'pay-per-use' fashion that leads to lower the capital expenditures (Krieger, 2007; Katz, Goldstein and Yanosky, 2009; Weber, 2011; Alshwaier, 2012; Benson and Morgan, 2013; Tarek and Ahmed, 2013). Due to its shared storage allocation mechanism, also termed as multi-tenancy, the platforms offer virtually unlimited storage and computation capabilities which can be accessed from anywhere at any time with universal access (Buyya et al., 2009; Armbrust et al., 2010; Weber, 2011; Masud, Yong and Huang, 2012).

Higher education institutions play an important role in the growth of societies. As with other organisations nowadays, universities have become more reliant on Information and Communication Technology (ICT) and internet-based services to provide their stakeholders with requested educational services. Cloud computing is likely to be an attractive proposition for educational establishments. The potential of cloud computing may include but is not limited to increasing service efficiency and cost-savings (Sultan, 2010; Alharthi *et al.*, 2015a).

An example is that the University of California (UC) at Berkeley, found cloud computing to be attractive for use on one of its courses that was focused exclusively on developing and deploying Software as a Service (SaaS) applications (Alshwaier, 2012). The Medical College of Wisconsin Biotechnology and Bioengineering Centre in Milwaukee found the use of cloud computing in their research very beneficial, providing it with massive computational power that exceeded their own limited hardware power. Researchers at the Centre have been undertaking protein research which has been made more accessible to scientists from anywhere in the world. This is due largely to renting Google's cloud-based servers (Sultan, 2010). Some universities have adopted cloud computing for

economic reasons. The Washington State University's School of Electrical Engineering and Computer Science (EECS) has suffered cuts in its budget. However, the EECS claims that despite the challenging economic climate, cloud computing has actually enabled it actually to expand the services it offers to faculties and students (Sultan, 2010).

Some universities are facing difficulties in providing scalable and flexible IT services. For instance, in traditional computer labs there are many challenges such as limitations of lab hours and seats during peak hours, repairing and maintaining computer labs, travelling to and from university, and the cost of fitting with traditional computer lab equipment (Truong *et al.*, 2012). Normally, IT services required by students, researchers and academics are requested from the IT department Figure 1-1.

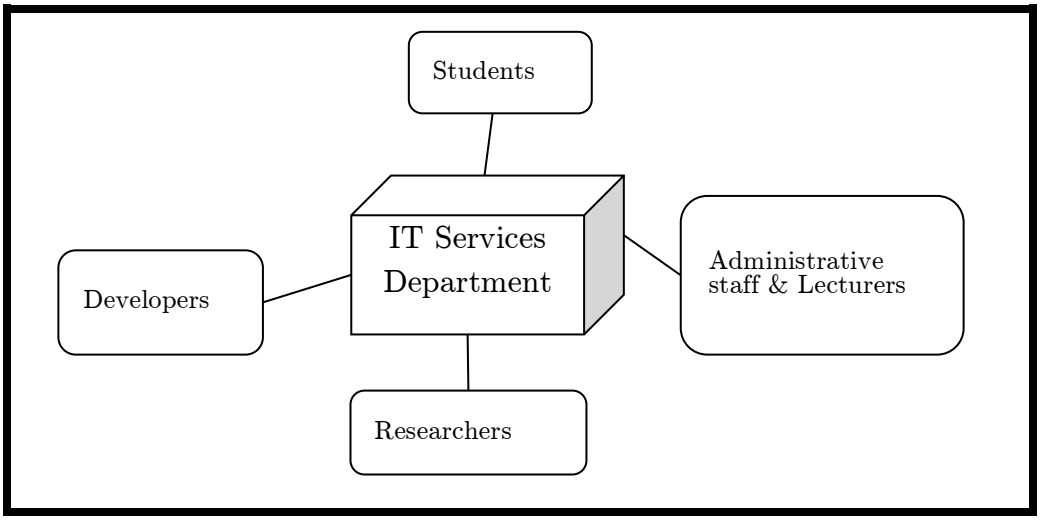


Figure 1-1: Users of Traditional IT Services in a University

However, in cloud computing all these arrangements can be migrated to the cloud as illustrated in Figure 2-1. The cloud resources can be accessed from anywhere and at any time through the Internet via using different cloud architecture services model such as Platform as service (PaaS), Infrastructure as service (IaaS) and Software as a service (SaaS).

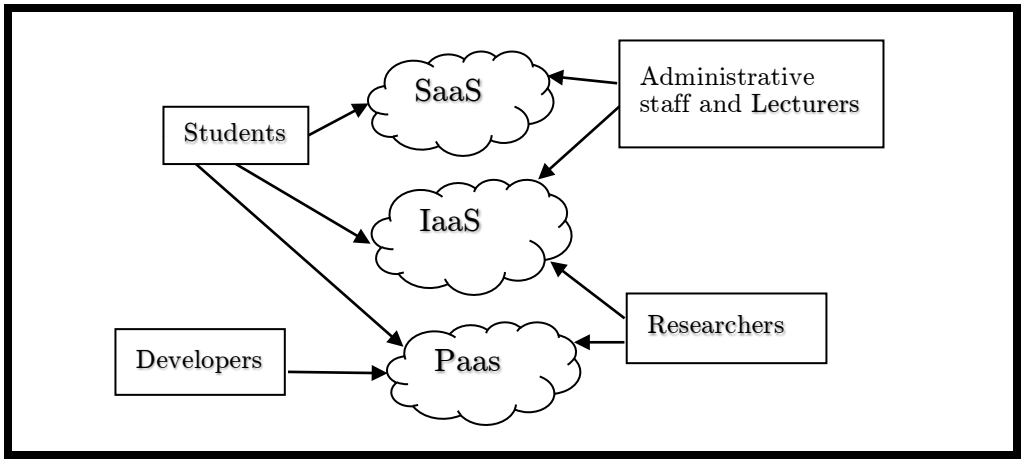


Figure 1-2: Users of Cloud-Based Services in a University (Mathew, 2012)

Universities around the world are become more interested in utilising cloud educational services. Recent statistics show that 70% of higher education institutions in North America have moved (or are in the process of moving) their email systems to the cloud and 50% have adopted a cloud-based collaboration system to improve information-sharing across campus (Katz, Goldstein and Yanosky, 2009). According to a survey by Educause (Wheeler and Waggener, 2009), nearly all higher educational institutions in the world have a major interest in adopting cloud-based solutions, at least at the level of some departments.

Cloud computing is widely used in European and American countries to deliver a better quality of higher education but Saudi universities are slowly seeking to promote cloud based higher educational environment for e-learning and distance learning platforms (Alshwaier, 2012; Tashkandi and Al-Jabri, 2015). The rapid growth of the young population in Saudi Arabia requires the universities to improve their ICT resources as soon as they can to provide the students and the academics with the ICT resources that they need to enhance their teaching and learning experience (Aljabri, 2012). This is further bolstered by the fact that cloud-computing resources can be scaled dynamically thereby providing unrestricted computing power for students as well as the academics. There is a need for agile, blended and flexible way to enhance the teaching and learning process to promote good quality research and job opportunities (Naif Jabil, 2013). In Saudi higher education, several studies have revealed a positive attitude amongst students, faculty, and university administrations toward the use of internet-based cloud services (Alharbi, 2012; Alotaibi, 2014).

Despite the immense benefits for universities by adopting the cloud, they may face several challenges including issues of data security and confidentiality, privacy and regulatory compliance, human resistance and legal aspects which cause the cloud migration project to fail thereby incurring serious losses. With regards to the legal issues, one instance of universities facing legal issues with the cloud adoption is Lakehead University, Canada's cloud adoption case. The university faculty had concerns about the privacy of its email system which was outsourced to Google and is based in the United States. The faculty union filed a grievance with the university that Google was subject to the American law and hence was liable to disclose their university data to the US government without gaining explicit permission. The grievance was under arbitration and was moved from internal arbitration to external arbitration with professional mediators to oversee the case. However there are no further information about the ruling results (Okai *et al.*, 2014).

Likewise, issues such as these hamper advancements in cloud-computing adoption. Consequently, the rate of adoption is still quite low. Such is the case in Saudi Arabia, where the slow rate of adoption can be attributed to a wide range of factors (Alsanea and Barth, 2014; Nouf Alkhater, Robert Walters, 2014). There are many studies about cloud adoption and migration in the literature in the context

of developed nations. However, there are relatively few efforts that relate to the exploration of cloud adoption challenges and drivers within the Saudi higher education context. Moreover, these studies have considered cloud adoption factors that hinder the adoption or facilitate it, which are largely focused on individual perceptions. However, the factors that are related to the transition or migrating to the cloud, which is a further step ahead after adoption, are neglected in the literature, and only one study appears to have investigated the success factors for implementing a private government cloud in the Saudi context (Alkhlewi, Walters and Wills, 2015a).

## 1.1 The higher education system in Saudi Arabia

Prior to February 2015, the Ministry of Higher Education (MOHE) was an independent body in Saudi Arabia, but now the education and higher education ministries have been merged under a single ministry that runs both the higher education and the general education.

In Saudi Arabia, there are 27 government universities. Each university consists of colleges and departments that offer diplomas and bachelors, masters and PhD degrees; some colleges and departments also provide distance learning. Each university has two different sections, separated into male and female departments. In Saudi Arabia, each university has a deanship of IT including different IT departments; their main role is providing ICT resources to the university stakeholders. Of these 27 universities only eight universities are mature universities and around 19 universities are start-up universities. According the Saudi Ministry of Higher Education, the start-up universities are those universities were established recently and still has not reached ten years anniversary since it is establishment whereas mature universities are the vice versa. Most of the start-up universities are scattered and located in rural places, cities and villages with limited budgets, infrastructure and employees. Moreover, these start-up universities are still lacking web-based e-learning and teaching tools in comparison to the established universities in Saudi Arabia (Ministry of Higher Education, 2016). Currently in Saudi Arabia, the use of distance education is maturing. Therefore, Higher Education institutions in Saudi Arabia need to evolve from traditional delivery methods, that is, lecturing and tutoring to cloud-based education in order to keep up with the latest educational services and tools (Alamri and Qureshi, 2015).

Saudi universities are still slowly seeking to promote cloud based higher educational environment for e-learning and distance learning platforms, although it is being widely used in European and American universities to deliver a better quality of higher education (Odeh, Warwick and Cadenas, 2014; Alamri and Qureshi, 2015; Karim and Rampersad, 2017). Therefore, It is important to investigate the challenges that hinder the cloud migration process and the critical success factors (CSFs) that will enable cloud migration in the Saudi higher education context. In Saudi Arabia, the successful implementation of cloud

computing projects in higher education institutions relies on the capabilities of top management, called the deanship of IT to drive organisational change actively through an official cloud migration strategy.

## 1.2 Research Problem

There is a growing recognition that services and applications previously executed on a local network are gradually finding their way onto the cloud. Many industry experts believe that cloud computing will become widely used in higher education (Wheeler and Waggener, 2009). At the same time, it is important to understand the distinctive features of higher education and this requires a careful evaluation of how and what kind of solution can be adopted (Cisco, 2012).

El-gazzar *et al.* (2014) conducted a systematic literature review on the topic of the processes or factors for enterprises in the area of the cloud adoption and migration. The authors classified the research in the area into eight categories under two domains: cloud adoption factors (internal and external) and cloud adoption processes such as proof of concept and adoption decision systems. The internal factors subdomain is defined as 'the internal capabilities of organisations that affect the migration process to the cloud which include issues pertained to evaluating the readiness of the organisation IT knowledge and skills of the human resources, IT infrastructure, available resources, and culture' (El-Gazzar, 2014).

The authors concluded the systematic review with future direction recommendations for the Information System (IS) researchers, and one of the areas suggested is: *'It would be insightful to investigate internal readiness and selection of cloud provider issues in the context of SMEs and/or large enterprises therefore there is a need for case studies providing recommendations for practice regarding internal preparation, service model selection, and contract negotiation issues.'* (El-Gazzar, 2014; El-Gazzar, Hustad and Olsen, 2016).

A study by Okai *et al.* (2014) was conducted to investigate the slow rate of cloud computing adoption at university level; the researchers in this study concluded that the most top reasons for failed cloud projects are:

A. Lack of proper planning and background study before migration
B. Lack of skilled IT personnel
C. Lack of experience to integrate legacy systems with cloud solutions

Moreover, the researchers suggested that in order to overcome the failure of the cloud project the universities need to consult cloud experts, assign proper IT team during the migration plan phase and understand their stakeholders' workloads (Okai *et al.*, 2014)

Due to the relatively recent emergence of the cloud computing paradigm, Saudi Arabia still lacks the core infrastructure required to move its traditional ICT to the cloud (Alkhlewi, Walters and Wills, 2015b). There is a lack of growth reported in educational services despite the financial means (Al-Nuaim, 2011). There is a wide range of challenges quoted including infrastructural, cultural and organisational factors that impede a successful IT project deployment in Saudi organisations (Aldraehim *et al.*, 2012; Alfaadel, Alawairdhi and Al-Zyoud, 2012; Alfarraj, Alhussain and Abugabah, 2013).

An e-government programme, Yesser has recently been launched by the Saudi government to simplify e-government services, However, even this programme has not yet fulfilled the whole objective of transitioning to e-government as it cited a weak public sector infrastructure to support IT initiatives (Alfarraj, Alhussain and Abugabah, 2013). Moreover, other 'systematic barriers' due to lack of public knowledge, lack of necessary security and privacy systems and lack of qualified IT specialists give a different perspective to the problem of cloud migration within the Saudi Arabian context (Alshwaier, 2012). Moreover, cultural aspects are also reported to change the nature of challenges involved in such projects substantially (Aldraehim *et al.*, 2012). Although, migration challenges and drivers have been investigated in different contexts in developed countries such as UK, USA and Australia (Odeh, Warwick and Cadenas, 2014) studies investigating the same issue in the Saudi context are scarce in general and particularly in the higher education settings (Karim and Rampersad, 2017).

There is however a rich research base regarding cloud migration issues available in the literature globally which can be used as a reference for the case of Saudi Arabia. However, due to a substantially different socio-cultural, political and government infrastructure, such a process would require detailed analysis, revalidation and empirical evaluation in order to fit it for the proposed context (Alshehri, Drew and Alfarraj, 2012). Therefore, the scope of this research lies with the exploration of the challenges and enablers in the domain of cloud migration internal preparedness within the context of Saudi higher education institutions by developing a framework that encompass various success factors related to the internal capabilities of the universities.

## 1.3 Research Aims and Objectives

Due to the scarcity of literature on the barriers and enablers of cloud migration projects in the higher education context in Saudi Arabia, this research is mainly aims to investigate cloud migration aspects and hence develop a framework to explore various factors that play critical roles in the successful migration of traditional ICT in Saudi Arabian universities to cloud Paradigm. These factors are termed in this research as Critical Success Factors (CSFs). The following research question and sub-questions are arranged to investigate the main aim of this research:

- **RQ1:** What is the appropriate cloud migration success factors framework for Saudi universities?
    - **RQ1.1:** What are the challenges of migrating universities' ICT to cloud paradigm?
    - **RQ1.2** What are critical success factors for cloud migration in Saudi Arabian universities?

By addressing the RQ1 and the belonging sub-questions, the researcher has confirmed the critical success factors framework (SFCM2). Based on SFCM2 and in order to validate it in real world settings, another aim of this research is to develop a readiness assessment instrument to measure the Saudi universities' readiness status for cloud migration. This milestone of the research was conducted in order to validate the confirmed framework in real world settings (three case studies) by converting the theoretical framework (SFCM2) into measuring assessment instrument called cloud migration readiness assessment (CMRA) in order to measure Saudi Universities' readiness. The following research question and its relevant sub-questions are arranged to investigate the second aim of this research:

- **RQ2:** Based on the confirmed framework, what is the appropriate instrument to measure the readiness of Saudi Arabian universities for cloud migration?

    - **RQ2.1:** What are the readiness assessment criteria and their measuring items for cloud migration?
    - **RQ2.2:** Based on the Saudi university requirements, what is the importance/priority of each of the readiness criteria in the proposed instrument?
    - **RQ2.3:** How good is the functionality and practicality of the CMRA instrument?

The abovementioned research questions are addressed by developing the following objectives to achieve the research aims:

- To review the literature on cloud migration approaches and frameworks critically while investigating the global context of cloud migration in the case of Saudi universities (RQ1, RQ2)
- To investigate challenges, issues and priorities of cloud migration and hence derive a set of critical success factors (CSFs) in the context of Saudi Arabian universities (RQ1)
- To develop and confirm a framework to identify key enablers to guide Saudi universities to succeed in their cloud migration project (RQ1)
- To develop, evaluate and validate an instrument to measure the readiness of any Saudi Arabian academic institution's ability to migrate to the cloud (RQ2)

## 1.4 Organisation of the thesis

This thesis is divided into eight chapters. This first chapter provides a general introduction to the research topic. Chapter 2 provides an overview of the related literature regarding the concepts and benefits of cloud computing and cloud migration issues, the success factors, the higher education cloud adoption context and the existing cloud migration readiness models. It also includes decision support systems for cloud migration. Chapter 3 describes the research framework development phases based on secondary data in Chapter 2, to identify the CSFs for cloud migration. Chapter 4 discusses the research methods undertaken to confirm the proposed framework and to evaluate and validate the research instrument. Chapter 5 reports on the empirical findings, results and discussions of the confirmatory study. Chapter 6 discusses the research methods and techniques used to develop the research readiness assessment instrument. Chapter 7 presents the findings and implications of the conducted case studies. In Chapter 8, general conclusions are drawn and potential future directions are presented.

# Chapter 2

# Literature Review

This chapter presents a review of cloud migration challenges and the various CSFs present therein. It starts by providing an overview of the cloud computing paradigm and then presents a critical review of the current research in the cloud migration topic, the review presents critical analysis and discussion on existing frameworks, models, decision support systems (DSSs) and existing research in organisation readiness assessment contributions covering various cloud migration issues. Subsequently, it provides reports on the benefits of current services of the cloud in the higher education institutions. The review then tightens its focus on the Saudi Arabian context and then explores various challenges that can be faced by Saudi universities during cloud migration. Lastly, the review widens to cover research efforts on CSFs in cloud migration projects.

## 2.1 Overview of the Cloud Computing Paradigm

Cloud computing has evolved from technologies such as virtualisation, grid computing, distributed computing, Web 2.0 technologies, Service Oriented Architecture and utility computing (Armbrust *et al.*, 2009). To have a deeper understanding of the cloud paradigm, several definitions for Cloud Computing have been introduced in the literature by the researchers. The three most cited definitions are presented below:

- Buyya *et al.* (2008) define Cloud Computing as:

'A type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers' (Buyya, Yeo and Venugopal, 2008).

- Vaquero et al. define Cloud Computing as:

'A broad array of web-based services aimed at allowing users to obtain a wide range of functional capabilities on a 'pay-as-you-go' basis that previously required tremendous hardware/software investments and professional skills to acquire' (Vaquero et al., 2008).

- National Institute of Standards and Technology (NIST) defines Cloud Computing as:

'A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction' (Mell and Grance, 2011).

Of these definitions, that by NIST is the most comprehensive as it encompasses the unique characteristics, service models and deployment models of the cloud

### 2.1.1 Cloud Characteristics

According to the NIST definition cloud technology has five characteristics; on-demand self-service, resource pooling, broad network access, rapid elasticity and measured services. More details about each characteristic are described in Figure 2-1

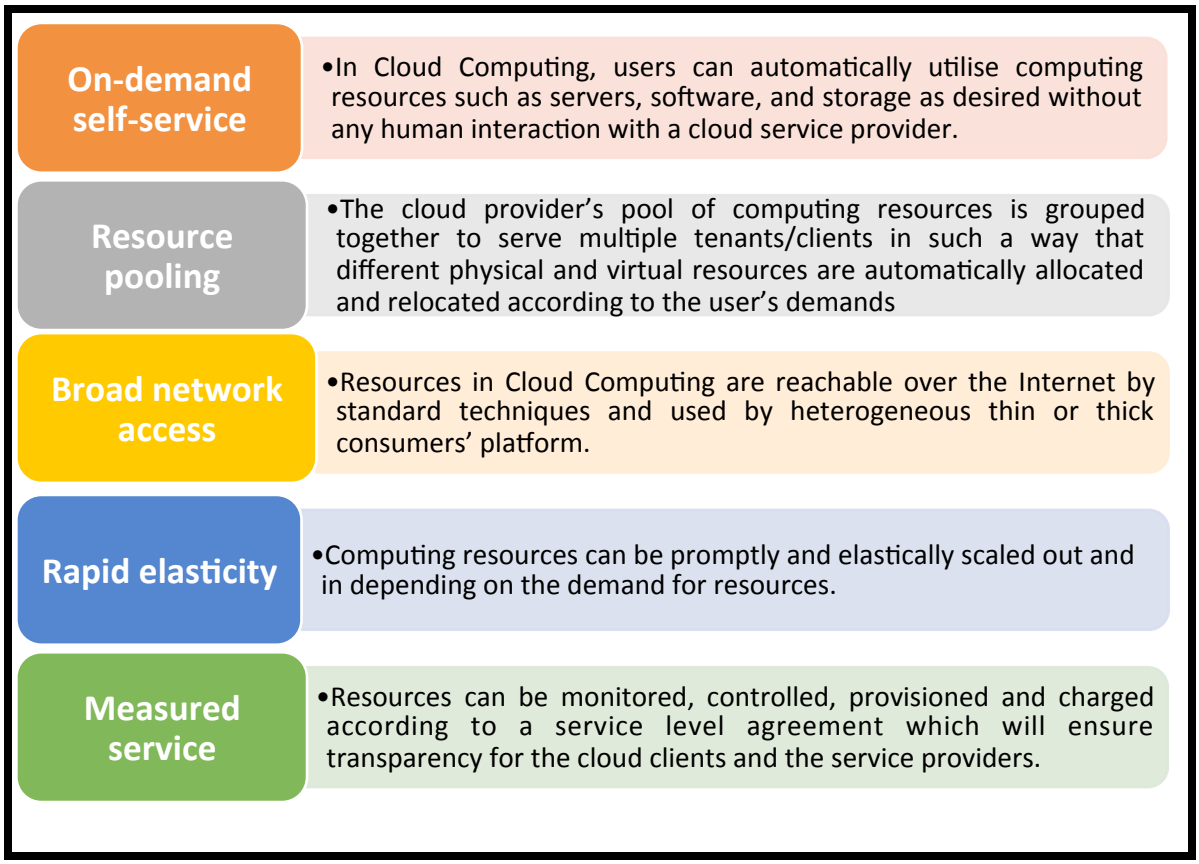


Figure 2-1: Five Essential Cloud Characteristics (Mell and Grance, 2011)

### 2.1.2 Cloud Deployment Models

There are four deployment models for cloud services services (Armbrust *et al.*, 2010; Mell and Grance, 2011), with derivative variations that address specific requirements. The four models are listed below:

1- **Public Cloud**: A single organisation generally owns the infrastructure. The infrastructure is made available to public or other organisations and is leveraged to provide different services.
2- **Private Cloud**: The infrastructure is utilised by a single organisation; hence, it is not made available to anyone outside the organisation. The infrastructure can either be managed by the organisation or another organisation may manage it on behalf of the first organisation.
3- **Community Cloud**: The infrastructure is shared among multiple organisations that may share a set of common goals and requirements among themselves. In this type of deployment, the members of the community managed the cloud infrastructure by using a pre-determined level of agreement.
4- **Hybrid Cloud:** The infrastructure is a combination of two or more other cloud models where particular application scenarios prohibit the usage of a single cloud model.

### 2.1.3 Cloud Services Model

Cloud computing has three main services as indicated in the NIST cloud computing definition as illustrated in Table 2-1.

Table 2-1: Cloud Service Models

| Services | Description |
|---|---|
| Software as a Service (SaaS) | This is the highest layer and comprises a complete application layer offered as a service, on demand, via multi-tenancy. For example, Salesforce, Facebook, LinkedIn, Intuit, Google Apps and Microsoft Office Live offer basic business services such as e-mail and messaging using the SAAS model (Buyya *et al.*, 2009). |
| Platform as a Service (PaaS) | Consumers using PaaS can develop and/or deploy applications by using provider's services and tools. PaaS providers provide tools for every phase of software development and testing which can be utilised to deploy any service quickly. Examples include Google App Engine and Microsoft Azure (Mell and Grance, 2011). |
| Infrastructure as a Service (IaaS) | Offers a means of delivering basic storage and compute capabilities as standardised services over the network. Amazon (AWS) and Rackspace are IaaS providers which provide servers, storage and other computing resources (Buyya, Yeo and Venugopal, 2008) . |

## 2.2 Review of Related Work in Cloud Migration

By using cloud services, enterprises can deploy their application systems over a group of independently managed resources. However, the majority of such organisations rely on their own custom needs which must be considered if they decide to use cloud-based systems (Jamshidi, Ahmad and Pahl, 2013).

Migration to the cloud refers to the process of moving applications, data, servers, and networks from in-premises to the cloud data centres (Wang and Hsu, 2013). This migration of ICT to the cloud can be partially conducted on some of the systems of the organisation. Alternatively, all the IT infrastructure can be migrated to the cloud (Buyya, Yeo and Venugopal, 2008). However, the process of migration still imposes a diverse range of risks and issues that must be considered in the overall global context of this process. The most challenging task in the

migration process is how efficiently these risks are identified and moderated. The most important phase in this process, as reported by Buyya *et al.* (2012), is encountered during the testing and validation phase of migration. This includes the identification of core migration risks which are then mitigated during the optimisation phase.

The overall risk mitigation process can broadly be categorised into two main issues: general migration risks and security-related risks. The former are further elaborated to address issues of economical evaluation (Mastroeni and Naldi, 2011), downtime prevention during migration (Svard *et al.*, 2011), handling legacy applications (Beserra *et al.*, 2012) and application migration challenges (Kolb, Lenhard and Wirtz, 2015). Extending further into the former category of general migration risks, a number of sub-challenges are to be identified and resolved (Buyya, Pandey and Vecchiola, 2012). These include issues related to performance monitoring and any side-effects that the process/system might encounter to facilitate business continuity and disaster recovery. Moreover, standard compliance, government issues, licensing requirements and quality of service-related parameters are also considered.

On the security side, the requirements go deeper into issues originating from trust, privacy, auditing and multi-tenancy, as well as the impact of data leakage. On the security-related risks domain, many areas have been investigated in the literature. In the event disaster recovery, a completely separate response is required for cloud-based systems. Traditional systems are known to rely on system snapshots, TCP/IP baseline and replication to provide support in case of emergencies. Chang (2015) introduced a novel 'multi-purpose' approach on the cloud to support big data recovery within the data centres by keeping redundant system snapshots at geo-located servers located in London, Southampton and Leeds to update and restore data simultaneously.

On the aspect of Data Centre Network (DCN) security handling issues (Wang *et al.*, 2015), the focus has primarily been on addressing multi-tenant demands and DCN routing, public key cryptography and SSL protocol implementation for distributed environments (Zhao *et al.*, 2014), implementation of the Cloud Computing Adoption Framework (CCAF) and infrastructure security auditing are a few areas to be considered during a migration process (Chang, Kuo and Ramachandran, 2016). Security as a service has focused more on issues of modelling the theory of planned behaviour to assess the readiness of people to adopt a new technological framework, such as that of the cloud. However, most of research in the domain of security as service is limited to cloud services and hence the case would be substantially different in the case of migrating other services to the cloud. Moreover, the majority of migration and security risk-related research considers security and privacy-related variables as a single entity which may assume a different concept in case of educational institutions. Migrating legacy systems to a cloud-based systems involves a number of procedures that must be

undertaken in a sequential manner as advised by Buyya *et al.* (2012). The process is termed a seven-step model of migration to the cloud and starts with the migration assessment phase. This is followed by the isolation of dependencies, environment mapping, making provision for lost functionalities, integrating cloud functionalities, testing and finally iteratively optimising the new environment.

### 2.2.1 Existing Cloud Migration Frameworks and Models

Application development environment migration assumes a different perspective when undertaken on the cloud rather than standard/local legacy networks. A Unified Cloud Migration Framework was proposed by Peddigari (2011) to migrate application development from on the premises to a cloud-based platform. The domain of application-level migration has further been investigated to explore issues of service migration patterns (Fehling *et al.*, 2013), legacy application migration within higher-level platforms such as Java and Python-based context (Vu and Asal, 2012), step-wise migration of IaaS (Beserra *et al.*, 2012), and an Application Migration Solution (AMS) framework to migrate to web applications via GUI recognition and construction tools (Meng *et al.*, 2011).

The research on seamless migration of legacy systems focuses on step-by-step models. However, The majority of these applications are restricted to context-specific applications, for example medical or telecommunication hence cannot be directly applied to other contexts (Beserra *et al.*, 2012; Vu and Asal, 2012). The majority of migration frameworks proposed in the literature are focused on technological factors rather than on measuring the readiness of a specific context to migration from legacy to cloud-based context. Wu, Wang and Gao (2014) address the issue of readiness within the context of business, technical and risk perspectives based on a fuzzy Analytical Hierarchy Process (AHP). However, the proposed work considers only private cloud settings and has not been empirically evaluated.

Within the e-government context, Kurdi *et al.* (2011) focus on the citizen to government relationship to assess the readiness of e-government via a set of high level guidelines. Yet, the assessment framework does not identify the key success factors or the measurements required to assist the migration of e-government services to the cloud. Although the authors claimed that their proposed comprehensive framework is validated and tested, no empirical data or evidence are presented. Additionally, in a number of assessment frameworks proposed in the existing literature, the focus has been on integrated agent-based frameworks to facilitate hybrid, public/private migration via automated agents (Fan, Wang and Chang, 2011). Extending further on the same challenge of the migration process, various Key Performance Indicators (KPIs) related to green business process reengineering (GBPR) were discussed by Wang and Hsu (2013) to elaborate on strategies and concerns encountered in an organisation's transformation to the cloud environment.

### 2.2.2 Current Cloud Migration Decision Support Systems

A review of research in Decision Support Systems (DSSs) in the cloud migration domain as illustrated in Table 2-2 shows that the majority of the proposed DSSs do not support an evaluation of current cloud environments and organisations' internal processes. That is, they focus on provider selection or the application of automation in migration to the cloud (Menzel and Ranjan, 2012; Andrikopoulos *et al.*, 2013; Garg, Versteeg and Buyya, 2013; Juan-Verdejo *et al.*, 2014).

Table 2-2: Existing Cloud Migration DSSs

| Proposed Methodology | Source | Decision Support Factors | Method | Support Type |
|---|---|---|---|---|
| **Suitability Analysis** | (Misra and Mondal, 2011) | IT resources size, Data sensitivity, and Services criticality | Return of Investment (ROI) Model | Financial perspective of cloud migration |
| **Migrating Application DSS** | (Andrikopoulos, Strauch and Leymann, 2013) | Providers' Features and migration cost | Conceptual model | Choice of cloud providers |
| **Adoption toolkit** | (Khajeh Hosseini *et al.*, 2012) | Cost, Responsibility, Stakeholders Impact, and Technology Suitability | Mainly cost modelling | Choice of cloud providers |
| **Migrating Application DSS** | (Andrikopoulos, Song and Leymann, 2013) | Cloud providers selection, Application migration cost | Three layers architecture online DSS | Choice of cloud providers |
| **Priorities cloud services** | (Garg, Versteeg and Buyya, 2013) | Key performance indicators such as assurance, performance and security | AHP based weights and rankings | Rank and compare cloud providers |
| **Migrating Application DSS** | (Juan-Verdejo *et al.*, 2014) | Organisations' criteria for application migration such as agility, assurance, cost, security, performance, and usability | Multi-criteria decision support modelling | Choice of appropriate cloud offerings |
| **Web applications migration criteria** | (Menzel and Ranjan, 2012) | Performance, Cost, providers' features | Mathematical modelling | Choice of cloud providers |

The majority of the decision support systems have either been developed for commercial objectives or are not openly available to the public (Khajeh Hosseini *et al.*, 2012). Though the provider evaluation and automation of traditional applications appears to be critical, thereby assisting their readers in making informed decisions, the actual process still requires the assessment of a wide range of factors pertaining to organisations' managerial and infrastructure readiness at the early stages of a decision process for cloud migration (Khajeh-Hosseini *et al.*, 2011).

Organisations moving to the cloud should have an in-depth awareness of their existing infrastructure capabilities, standards, policies, threats and human resources, before arriving at a decision and undertake the actual migration process. Hence, few considered various aspects related to the organisations decision-making process (Misra and Mondal, 2011; Khajeh Hosseini *et al.*, 2012).

Additionally, existing research focuses on migrating from local, legacy systems to the cloud, and there appears to be a lack of interest in intra-provider migration. This aspect must be given its due importance, since the issue of vendor lock-in which is indeed a concern for many users (Opara-Martins, Sahandi and Tian, 2016). It can be seen from the analysis of the current DSSs in the literature that little of the research reviewed so far considers the CSFs related to the technological and organisational aspects and their potential role to increase the likelihood of cloud migration project success. Hence, the provision of a validated measurement instrument can substantially assist in the cloud migration decision support process, which is one of the objectives of this research.

### 2.2.3 Cloud Migration Readiness Assessment

Organisational readiness in cloud migration is considered an active area of research. A metric to evaluate enterprise readiness for cloud computing adoption was developed by Kauffman *et al* (2014). The work considered four dimensions in cloud adoption namely: technology and performance, regulation and environment, organisation and strategy and economics and evaluation. The metric focused more on the factors that affect organisation readiness than providing further empirical investigation, as the research was still in progress (Kauffman, Ma and Yu, 2014).

In a similar context, different Capability Maturity Models were proposed to assess organisations' readiness to adopt cloud computing (Alonso *et al.*, 2013; Duarte and Da Silva, 2013; Surya and Surendro, 2014). However, the focus of these proposed models has largely been limited to software companies for application migration aspects only, although some effort has been focused on higher education in Indonesian universities (Surya and Surendro, 2014).

These studies address different contexts related to cloud readiness or undertake different validation approaches for their proposed readiness measurement models that do not take CSFs into account. Extending further on the same challenge of the migration process, various Key Performance Indicators KPIs pertaining to green business process reengineering GBPR were investigated by (Wang and Hsu, 2013) to elaborate the strategies and concerns encountered in an organisation's transformation to the cloud environment. However, the proposed framework is still unverified by any empirical methods.

Research in cloud readiness assessment covers migration applications and strategic level considerations. In the context of cloud applications migration, Corradini *et al.* (2015) present an assessment metric for legacy cloud applications prior to migration. Moreover, Loebbecke, Thomas and Ullrich (2011) present a Cloud Readiness Method which uses an IT company as a case study to evaluate their services for their cloud readiness status. However, this study only evaluates the IT systems not the human, legal and organisational aspects of cloud migration. On a strategic level, the focus was on designing a framework to address cloud

governance challenges and the identification of IT management and data security impact (Palvia, 2013; Brandis, Dzombeta and Haufe, 2014).

The studies reviewed in this section reveal limitation coverage of factors drawn from cost, risks and economic implications. The factors, hence, do not address aspects of policy, compliance or SLAs' requirements. On the technical aspect, factors such as interoperability, reliability and other security-related issues are either ignored or not designed as measurements to assess cloud migration readiness.

## 2.3 Benefits of Cloud Computing for Higher Education

The following section describes some benefits of using cloud computing in Higher Education institutions and the features of cloud services compared with the traditional IT provision paradigm. According to NIST, cloud computing enables greater returns on data centres' investments by using IT resources more efficiently (see Table 2-3).

Table 2-3: Traditional ICT resources Vs. Cloud Resources

| Feature | Traditional ICT Resources | Cloud Resources |
|---|---|---|
| **Acquisition Model** | Buy Assets and build Technical Architecture | Buy services |
| **Business Model** | Pay for fixed assets and administrative overheads | Pay as you go and for what you use |
| **Access Model** | Internal network, intranet, or corporate client | Internet, any device |
| **Technical Model** | Single tenant, static | Multi-Tenant, shared, dynamic/elastic |

In addition, implementing new ideas and innovations become easier and more agile with cloud computing than with traditional methods (Buyya *et al.*, 2009; Armbrust *et al.*, 2010; Mell and Grance, 2011).

Higher Education can also benefit from the scalability and agility offered by cloud computing, thereby enabling researchers to try out and implement their ideas faster and at lower cost (Cisco, 2011). Cloud Computing offers services that enable the universities to concentrate more on teaching and research activities rather than building on complex IT configurations and software systems (Sultan, 2010). Students can exploit different learning tools.

Students already use some cloud-based services, such as Google Docs and Office365 and Windows Azure Platform for computer science students (Ercan, 2010). A summary of the benefits of cloud computing services to various stakeholders in higher education institutions that implement cloud services are listed in Table 2-4.

Table 2-4: Reported benefits of cloud services in Higher Education

| Cloud Advantage | Description | Sources |
|---|---|---|
| **Benefits for universities' ICT business model** | | |
| **Hardware cost reduction** | On-demand and □pay-per-use□ fashion of cloud computing is better for universities than the investment of an expensive and non□scalable infrastructure, where the utilisation of such an infrastructure might be very low at certain times during the academic year. | (Krieger, 2007; Weber, 2011; Alshwaier, 2012; Tarek and Ahmed, 2013) |
| **Storage and sharing** | Learning outcomes and resources can be stored in the □cloud□ which provides almost unlimited store and computation capacities. Documents can be commonly edited and shared in the □cloud□ such as services provided by Google Docs, live SkyDrive, and Office Live. | (M. Alabbadi, 2011; Weber, 2011; Hossain Masud and Huang, 2013) |
| **Administration & productivity improvements** | Ability to focus on core business activities and free-up management and IT personnel from mundane tasks (such as hardware support activities)<br>Also reduced risks of technological obsolescence as cloud providers update the infrastructure. | (Educause, 2010; Cisco, 2011) |
| **Benefits for universities' students** | | |
| **Universal access** | Learners can study and access resources anywhere/anytime/any device (desktop, laptop, mobile etc.) to computational resources and applications which can be setup without too much effort. | (Abdul Razak, 2009; Alshwaier, 2012; Mathew, 2012) |
| **Collaborative interactions** | Learners can cooperate anywhere in the □cloud□ From social learning perspectives, they can collaboratively build common knowledge through frequent and convenient interactions. | (Alabbadi, 2011; Alshwaier, 2012; Cisco, 2012) |
| **E-learning enabled** | E-learning is heavily people-oriented, which meets the individual needs of learners. Learners in the □cloud□ select suitable resources and can track their learning progress and outcomes. | (Basal and Steenkamp, 2010; Weber, 2011; Alshwaier, 2012; Yamin, 2013) |
| **Benefits for other universities' stakeholders** | | |
| **Flexibility** | Lecturers may exploit the benefits of flexibility as the cloud provides a superior platform from which to prepare their teaching portfolio presentations, lessons, conferences, articles, and so on. Researchers may also benefit from the advantages of using the latest technologies and hardware to do their experiments, while paying for using these services only on demand. | (Mircea and Andreescu, 2011; Sultan, 2010). |
| **Applications and infrastructure capabilities** | Developers can design, build and test applications on the infrastructure of the cloud service provider and produce those applications to the end users from cloud provider data centres. System administrators can leverage processing, storage, database management and other resources available on the cloud. | (Sultan, 2010; Huang, 2012) |

## 2.4 Cloud-based Educational Services

The trend of educational cloud computing has been led by top IT companies. Microsoft, Google, Amazon and IBM have provided many initiatives to support education institutions with the necessary learning tools. Some of these initiatives are free at no cost! Table 2-5 shows some of the existing educational clouds and tools. With the availability of content online, it is unnecessary for lecturers to print teaching materials.

### • Microsoft Education Cloud

Microsoft Education Cloud has been actively developing educational cloud services such as Microsoft Office 365. It provides schools with free email and websites with editing and storage facilities, instant messaging, web conferencing and 25 GB of personal storage (Jay, 2014). Furthermore, students and faculty are able to use any browser to create documents using Microsoft Office (David, 2013). The downside to Microsoft 365 is the cost. While a free option is available (with a signed contract), a per user monthly payment is required to access features such as Office Mobile, Office applications for PC or Mac, unlimited email storage and voicemail (Jay, 2014).

### • Google Education Cloud

Google Apps for Education is one of the most used applications. Some of the features include cloud email, 30GB of storage, hosting, word processing and collaboration tools (Google, no date). Google is Microsoft's strongest competitor. If it is compared to Microsoft's Office Suite, there is an existing familiarity with many of Google's products such as Gmail, Chat and Calendar. Nevertheless, the main drawback is that it requires users to have (or create) a Google account.

Table 2-5: Educational Cloud Applications (Abdul Razak, 2009; Alshwaier, 2012)

| Project Name | Education cloud apps | Features |
|---|---|---|
| **Microsoft Education Cloud** | Microsoft Live@edu | • Website Creation<br>• File sharing<br>• Word processing<br>• Desktop sharing Resource<br>• Scheduling |
| **Google education Cloud** | Google Apps Education (GAE) | • Google Mail<br>• Google Sites<br>• Google Docs<br>• Google Video<br>• Google Calendar<br>• Google Talk |
| **Earth˙browser** | Earth Browser | Provide real time data for weather, geological and other data |
| **Socratica** | Socratica | Classrooms in science to access<br>Create and study modules |
| **VMWare** | Virtual Desktop | Provide Virtual Computers |
| **IBM cloud academy** | Virtual Computing Lab | Smart Analytics System |

• Earth Browser

According to Earth Browser website, Earth Browser is a virtual globe software developed by Lunar software. It is available online as a three-dimensional navigator with real-time weather, and can be surfed on the website or be installed locally as an application (EarthBrowser, 2015). It focuses mainly on visualising geophysical information such as weather, earthquakes and so on. It shows the Earth as satellite images. Earth Browser can be used in real-time as it illustartes the object as a three-dimensional model with continuously updated information (EarthBrowser, 2015). The representation of planet Earth is rendered along with a large volume of data that is claimed to be accurate. The object can also be rotated and zoomed to a given distance.

• Socratica

According to Socratica's website, they claims that the company produces high-quality educational videos for people of all ages (Socratica, no date). The provided videos are characterised by high-definition and attractive attributes. The Socratica method of promoting education is that by collecting and organising the best free educational videos into topics that can be used by users. According to the website, Socratica's mission is to organise educational videos in order to provide students with centralised access to the content of thousands of videos to create an optimised learning experience. The videos are organised and some are restricted for suitable age groups on different channels on YouTube.

• Virtual Desktops

In computing, a virtual desktop is known as another user interface that is able to provide user with the virtual space of a computer's desktop environment through the use of a software application installed in a user's physical computer (VMware, no date). Generally, there are two ways to expand the virtual area of the screen. The Virtual desktops are switchable allowing users to create virtual copies of their desktop; this can be done with open windows on desktops. Another approach can expand the size of one virtual screen to more than the physical viewing device. Usually, navigation of an oversized virtual desktop is by using scrolling/panning into the subsection of the virtual desktop. One of the most popular VMware product is VMware Horizon 6. It provides a virtual desktop infrastructure (VDI) platform that provides virtualised and remote desktops and applications system through a single platform, giving users access to their online resources through one integrated workspace (VMware, no date).

• IBM cloud academy

IBM cloud academy is a collaborative community of leaders in education. It is intended for educational institutions, with the goal of helping to reduce costs and

optimise services while making information available, and secure if needed (IBM, no date). It can also be used to consolidate resources, improve student success and accelerate scientific discoveries. On the management side, it is expected to add administrative efficiencies and conserve resources. Users can actively integrate cloud technologies into their infrastructures to share best practices in the use of clouds and to collaborate with partners to create innovative cloud technologies and models (IBM, no date).

## 2.5 Cloud Computing Status in Global Higher Education Institutions

Statistics show that 70% of higher education institutions in North America have moved (or are in the process of moving) their email systems to the cloud and 50% have adopted a cloud-based collaboration system to improve information sharing across campus (Katz, Goldstein and Yanosky, 2009). According to Truong *et al.* (2012) most of higher educational institutions in USA and Europe have a major interest in adopting cloud-based solutions at least at the level of departments.

For instance, the University of California (UC) at Berkeley found cloud computing to be attractive for use in one of their courses which was focused exclusively on developing and deploying SaaS applications (Alshwaier, 2012). The Medical College of Wisconsin Biotechnology and Bioengineering Centre in Milwaukee found the use of cloud computing in their research very beneficial and provided them with massive computational power, which exceeded their own limited hardware power. Researchers at the centre have been undertaking protein research which has been made more accessible to scientists from anywhere in the world. This is due largely to renting Google's cloud-based servers (Sultan, 2010; Alharthi *et al.*, 2015b).

Some universities have adopted cloud computing for economic reasons. The Washington State University's School of Electrical Engineering and Computer Science (EECS) has suffered cuts to its budget. However, the EECS claims that despite the challenging economic climate, cloud computing has actually enabled it to expand the services it offers to faculties and students (Sultan, 2010).

## 2.6 Cloud Computing Status in Saudi Arabia

The IT market in Saudi Arabia is considered to be the largest IT market in the Gulf region, valued at approximately US $3.4 billion dollars in 2008 and expected to rise to US $5.6 billion by 2013. This is further expected to raise further, as International Data Corporation (IDC) has predicted that the ICT market in Saudi Arabia is going to reach US $33 billions by the end of 2017 (IDC, 2017).

In 2009, Market Research organisations indicated that the Saudi government had allocated a fund of US $3.1 billion to improve the quality of the country's

education system. The fund was to develop educational institutions with the best technological and scientific facilities (Market Research Report, 2009).

With regards to cloud computing adoption in Saudi Arabia, there is a noticeable public interest in adopting the cloud. However, this shift to the cloud in the Saudi context was conducted without adopting methodologies that suit the national context. Hence, considerable effort is needed to adopt the cloud in the Saudi government context (Karim and Rampersad, 2017).

The IDC forecasts the cloud market in Saudi Arabia between 2013 and 2017. It predicted that the usage of cloud service in Saudi Arabia would reach an equivalent of 57.7% of compound annual growth rate during these five years (IDC, 2012). In the IDC report (2012), it was stated that the top popular cloud deployment model that Saudi organisations had adopted is the private cloud, due to data security and control concerns.

The Saudi government is focusing on enhancing the e-government services provided to the public. Therefore, the government has started to embrace cutting-edge technologies such as cloud computing and the Internet of Things for smart cities to promote its e-government services. The Saudi government has initiated a nationwide cloud project that aims, as mention in its website *'... to provide Saudi government agencies with different ready, highly efficient, reliable and secure IT infrastructures, platforms and services'* (Yesser, 2017).

In Saudi Arabia currently, there are two telecommunication companies that provide cloud services (Alsanea, 2015). However, there are many challenges still to be tackled such as data ownership policies and cloud national regulations and strategies. Responding to the lack of cloud regulations in Saudi Arabia, the Communication and Information Technology Commission in Saudi Arabia (CITC) has proposed new regulations to support cloud computing developments in Saudi Arabia (CITC, 2016).

### 2.6.1 Cloud Computing Research in Saudi Arabia Higher Education

There are few research studies related to the cloud services in the Saudi Higher Education context. Most of these studies consider individuals' perceptions of cloud adoption. Moreover, the focus in the literature is domains of e-government and e-commerce settings, and there is lack of studies on the higher education context, as illustrated in Table 2-6.

Al-Somali and Baghabra (2016) surveyed IT professionals working in both private and government organisations in Saudi Arabia to investigate cloud application adoption models.

Table 2-6: Existing research in cloud computing within Saudi Arabian context

| Source | Study Aim | Industry Type |
|---|---|---|
| (Al-Somali and Baghabra, 2016) | Intention to use Cloud-based Application | Saudi organisations |
| (Mezghani and Ayadi, 2016) | Managers attitudes | Saudi Firms |
| (Yamin and Almakrami, 2015) | Cloud computing applications | Saudi firms Saudi SMEs (Small & Medium sized Enterprises) |
| (Tashkandi and Al-Jabri, 2015) | Cloud computing adoption | Saudi higher education institutions |
| (Alhammadi, Stanier and Eardley, 2015) | Knowledge base decision making strategy for cloud computing migration | Saudi Firms |
| (Alsanea and Barth, 2014) | Cloud computing adoption | Saudi Government Sector |
| (Alamri and Qureshi, 2015) | Usability of cloud computing | Saudi Higher Education Institutions |
| (Alkhater, Walters and Wills, 2015) | Cloud computing adoption | Saudi enterprises |
| (Alotaibi, 2014) | Cloud computing users' attitudes and intentions | Individual Users |
| (Alharbi, 2012) | Users' acceptance of cloud computing | Individual Users |
| (El-Sofany, Al-Oatibi and Alsa, 2012) | Patient records exchange | Individual Users |
| (Alshwaier, 2012) | How cloud computing usage can benefits the e-learning | E-learning domain |
| (Areshey, Alshwaier and Alshuwaier, 2012) | Educational applications of cloud computing | Saudi Education Sector |
| (Chanchary and Islam, 2011) | A model for Cloud based e-government with rational inference system | Saudi E-government |

They discovered that technological access, perceived threats, personal characteristics and social aspects play a significant role in using cloud computing services. Mezghani and Ayadi (2016) investigated factors causing negative attitudes in Saudi commercial companies. The findings reveal a focus on factors promoting negativity, and that positive perceptions, such as ease of use, perceived benefits and usefulness, lead to a positive attitude towards cloud adoption. Yamin and Al Makrami (2015) focused on exploring the extent of cloud computing applications' usage in SMEs in the West Coast of Saudi Arabia. The analysis in the survey revealed a critical need to upgrade existing computing infrastructures in Saudi Arabian SMEs with a cloud-based paradigm. Alhammadi, Stanier, and Eardley (2015) present a knowledge based DSS to assist decisions on cloud-computing migration.

Alsanea (2015) and Chanchary and Islam (2011) focused on the Saudi government sector where Alsanea (2015) investigated the factors that affected the adoption of cloud computing in the Saudi government domain and proposed a roadmap that could guide government organisations to adopt cloud computing effectively. Chanchary and Islam (2011) discussed existing Saudi e-government systems and proposed a cloud-based model with a rational inference agent that is expected to be more user friendly. El-Sofany, Al-Otaibi, and Alsanea (2012) proposed a model for Saudi hospitals patient records exchanges using cloud computing based architecture. The authors concluded that the proposed model can save patients medical costs and time, and assists them to access their medical records history from anywhere using a web client. Tashkandi and Al-Jabri (2015) explored factors

affecting cloud adoption in Saudi universities, and findings revealed that data privacy, complexity and relative advantage are the most significant factors affecting the usage of cloud computing.

Alamri and Qureshi (2015) explored reasons and needs behind adopting cloud computing in the Saudi Arabia higher education context in order to discover barriers to the learning process. The findings showed a significant improvement for professionals working in the industry and academia. Alshwaier (2012) discussed e-learning education in the Saudi Arabian context, gaining from cloud computing with respect to cost, efficiency, security, reliability and flexibility, while Alshuwaier, Alshwaier, and Areshey (2012) assessed applications and classified a number of educational and research issues in production and assessed the application of cloud computing models in the relevant higher education organisation.

According to current research reviewed in the domain of higher education in Saudi Arabia, none of the studies has considered the aspects of cloud migration critical success factors in the Saudi Arabia higher education context or investigated the readiness of Saudi universities to migrate their ICTs to the cloud environment.

### 2.6.2 Potential Challenges of Cloud Migration in Saudi Arabia

In this section, a list of the potential challenges is identified from the literature and the impact is discussed in terms of hindering the adoption of cloud computing in the Saudi universities context. These challenges can be mapped as the most important challenges that Saudi universities may face when they consider migrating their ICT services to the cloud:

#### 1. Provision of data control and service availability issues

Migrating to the cloud primarily involves issues of control, loss of data, service and availability. One of the main concerns in higher education relates to who controls the data. Cloud computing makes it possible to deliver everything in digital form. Copyright law and patent law strive to protect the intellectual property of owners. Course content, instructional framework and syllabi are made transparent and accessible to all. However, Saudi universities should have cloud providers to define their data recovery and business continuity positions in detail, particularly regarding what they are responsible for during a disaster affecting their data centres. Once the location is decided, they need to consider the 'availability' part. Authorised users need assured access to information, and cloud storage must be designed to be a robust and continually backed-up environment for data. The cloud has become a data repository but it is also a single point of failure. A loss of Internet connectivity anywhere between a university customer and their cloud provider's network will cause interruptions of varying severity. Users of Gmail faced a service outage in September 2013 for one day due to dual network error

and this indicates that even the biggest and most ubiquitous clouds can sometimes fail (Mircea & Andreescu, 2011; Shakeabubakor, 2015; Weber, 2011).

## 2. Challenges of applying security protocols during migration

Privacy and security remain the top concerns for higher educational institutions planning to adopt cloud computing, due to the migration of proprietary and sensitive data to beyond the campus walls. Issues of anonymity, compliance, integrity, reliability and auditability must also be considered in a migration process; hence the importance of security within a university IT environment is foremost. Nearly one-third of IT professionals in higher education identified potential security breaches as the single biggest barrier to cloud adoption. With so many concerns over security, privacy, and compliance in higher education jurisdiction, it is highly likely that the situation will also raise problems with the policy makers and stakeholders in the Saudi context (Cloud Security Alliance 2011; Mircea & Andreescu 2011; Alshwaier 2012; Weber 2011).

## 3. Legal policy constraints and compliance

In addition to the usual security concerns for any enterprise, educational institutions, by virtue of their diverse operations, are subject to numerous compliance regimes and when it comes to compliance, universities can outsource responsibility but cannot outsource accountability (Cloud Security Alliance, 2011). Accountability within Saudi organisations is generally attributed on individual basis that can be different from other global enterprise cultures hence it has great significance. Universities, in general, have indirect administrative responsibility for the security of their data and applications and are accountable for data breaches. However, in the Saudi context, data privacy is driven strongly by government initiatives directed at the organisation responsible. Universities' data or applications are stored at remote destinations and education directors need to know where their data will be hosted, because any large-scale implementation of cloud services by educational establishments may have to wait until law-makers begin to address the legal issues related to privacy and data protection in the context of cloud computing (Alshwaier, 2012; Koch, 2014). Again, as the onus of responsibility in Saudi context is more on organisations level, the burden of compliance stays with the organisation too, hence there are likely to be accountability issues during the migration process.

Due to a lack of clear legal policies for higher education in Saudi Universities, cloud users and providers will need to be more careful in their approach to cloud computing in order to prevent disasters and will be need to make sure that due diligence is carried out. This involves developing an institution-wide cloud strategy to help the institution to select the right sourcing and solution strategies. Saudi universities are subject to numerous state and national laws covering data on academic grades, health records and financial aid, among other things. Saudi Arabia has very strict rules about cross-border transfers of personal information,

and complying with those rules can be challenging in the virtual world of the cloud (Alkhazim, 2003; Baki, 2004; Koch, 2014).

Because data centres powering cloud computing platforms frequently exist in multiple nations, this triggers multi-jurisdiction issues that can pose additional complex regulatory constrains that may slow the Saudi universities' decision to migrate to the cloud. Higher education institutions in Saudi Arabia hold sensitive digital data, including government contracts, research materials and intellectual property, which are not allowed to be outsourced beyond the country border (Baki, 2004; Krieger, 2007).

### 4. Vendor lock-in and performance

Unlike traditional software packages that can be installed on a local computer and are available as long as the operating system supports them, cloud-based applications are services offered by companies and service providers in real time. Saudi Universities need to be able to trust that the service provider will continue to be there even in the face of a changing market they need to know the cost and efforts that they will face if they need to perform cloud cross-vendor migration or return to traditional, physical ICT provision. Typical cloud agreements define service level agreements (SLAs), establishing providers' expected up-time, usage agreements, technical supports, security liabilities and performance measurements. Universities should look at those agreements and measurements to understand what they actually mean in terms of end-user experience and the customer's operations (Onsman, 2010; Cisco, 2012; Masud, Yong and Huang, 2012; Song, Shin and Kim, 2013).

### 5. Cross-platform interoperability

Higher education institutions serve students, faculty staff and administrative staff who come to campus with their own devices and expectations about how and when they want to use them. The 'BYOD' ('Bring your own device') initiative poses many challenges for IT departments. IT staff must now provide greater interoperability between campus and stakeholder platforms 24/7 access to secure, reliable networks; and the ability to create, deliver and share content campus-wide on any number of devices. Cloud computing is now as much about meeting student needs as it is about running an efficient campus (Dillon, Wu and Chang, 2010). In the Saudi context, staff members and particularly students are likely to have a diverse range of machines. Hence, an email client, for instance, from a Mac OS must not have any compatibility issues with a MS Exchange Server hosted on the cloud platform. Thus cross-platform compatibility must be considered during the migration process (Quan *et al.*, 2012).

### 6. Users acceptance and awareness of new cloud-driven paradigm

User acceptance and awareness involves developing a staffing and organisational model to accommodate the changing IT environment and facilitate openness. This will provide agility to increase the awareness and training sessions to support university stakeholders. Another challenge to widespread adoption of cloud computing is a possible he vagueness and resistance among staff. It is widely known that introducing a new innovation can result in employee resistance, particularly if there is a lack of understanding of the change or indeed a lack of knowledge on how it will affect their work; for instance, there may be a fear of eventual downsizing (Sabi *et al.*, 2016).

Similarly, in the Saudi context, staff members are known to assume positions for decades. Hence, they become used to company cultures, technological routines and standards. Therefore, any potential migration to a seemingly new paradigm is likely to cause resistance, and senior decision-makers need to prepare employees for this new learning curve by providing training and communication in advance of cloud implementation (Katz, Goldstein and Yanosky, 2009; Masud, Yong and Huang, 2012; Mitchell and Cunningham, 2014; Sugawara and Nikaido, 2014).

Most of the abovementioned challenges apply to globally as well as Saudi context. However, a few were found to be directly unique to the Saudi higher education context. These unique challenges mainly included aspects such as Arabic languages integration. The formal language in Saudi Arabia is Arabic which is used in all official communications and hence its integration in the cloud is a challenge. Likewise, human resources working in the universities do not primarily have the experience and awareness of cloud services' administration. Most importantly, there are no regulations for using the cloud on a national level so far. There is only one decree that guide all government sector organisations to prevent cloud outsourcing outside Saudi borders. These points are further discussed in the confirmatory study in Chapter 5.

## 2.7 Research in critical success factors (CSFs)

De Sousa (2004) indicates that the critical success factors (CSFs) approach was established over the past thirty years, and was introduced first by Rockart (1979). Nowadays, the approach is widely used by Information System (IS) departments and consultants to provide a support to IS strategic planning. The increased attention to the concept of CSFs in the IS literature was due to the fact that *'CSFs can have a major influence on the design, development and implementation of IS'* (De Sousa, 2004).

In the literature there are several definitions for CSFs. Rockcart (1978) was the first researcher to introduce the term: *'Critical Success factors are the limited*

*number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization'* (Rockart, 1978).

Another definition for CSFs is provided by Bruno and Leidecker (1984) as *'those characteristics, conditions or variables that, when properly sustained, maintained, or managed, can have a significant impact on the success of a firm competing in particular industry'* (Leidecker and Bruno, 1984). Pinto and Slevin (1987) define CSFs as *'factors which, if addressed, significantly improve project implementation chances'* (Pinto and Slevin, 1987). However, both of these definitions lack the comprehensive concept proposed by Rockart (1978) that highlights a perfect link between environmental conditions and business characteristics for a particular firm (De Sousa, 2004). In the CSFs approach research, most of the studies are limited to IS implementation, requirements, and Project management topics and hence usually used by IS consultants or executives. This fact is confirmed in a study undertaken with 263 respondents and the major fields that the CSFs approach used were: IS requirements (47.6%), IS implementation (49.2%) and project management studies (63.4%) (De Sousa, 2004). To identify relevant CSFs to certain research topics, according to De Sousa (2004) several research methods can be utilised, as described in Table 2-7.

Table 2-7: Research methods used in identifying relevant CSFs

| Research Method | Sources |
|---|---|
| **Structured Interviews** | (Bullen and Rockart, 1981) |
| **Multivariate Analysis** | (Tishler *et al.*, 1996) |
| **Case Studies** | (Holland, Light and Gibson, 1999; Sumner, 1999) |
| **Literature Review** | (Esteves and Pastor, 1999; De Sousa, 2004) |
| **Group Interviews** | (Khandelwal and Ferguson, 1999) |
| **Questionnaire** | (De Sousa, 2004; Shah *et al.*, 2005) |
| **Delphi Technique** | (MacCarthy and Atthirawong, 2001) |

### 2.7.1 CSFs research in cloud computing

Only a few papers have investigated the CSFs of implementing cloud computing. Focusing on the organisational aspect of the CSFs in SMEs is the work by (Abdollahzadehgan *et al.*, 2013). Despite addressing technological readiness in addition to top management support and firm size, the work covers the former only as part of the organisational aspect not independently. The work also lacks empirical evaluation of the proposed framework. Comparatively, the work by (Garrison, Kim and Wakefield, 2012) empirically investigated the role of technological, managerial and relational aspects of cloud deployment success. The work forms its basis from surveys through on-site interviews, online participation

and telephone interviews to deploy the underlying model empirically. The participants were mainly IT managers from various industrial sectors. The outcome represented the importance of those aspects in exploiting cloud-computing resources to maximise the likelihood of deployment success. The outcome also revealed a direct link between trust management and technical capability, having a significant relationship with cloud-deployment performance.

Similarly, research in the e-government domain in the Saudi Arabian context reveals a potential benefit of deploying a private government cloud (Alkhlewi, Walters and Wills, 2015a). The authors proposed a success factors framework to investigate the facilitating aspects in deploying a private government cloud for the Saudi government. The framework comprised of 10 factors covering aspects ranging from project planning and leadership to reliability and security. The work was then extended to an expert review where the authors conducted interviews and questions the outcome of which was then merged to confirm their proposed framework. The results highlights the importance of 10 initial factors identified by the literature review and 5 additional factors suggested by the participants including communication, information exchange standardisation, training, knowledge management, and business continuity and disaster recovery plans (Alkhlewi, Walters and Wills, 2015b).

Despite substantial effort being put into cloud adoption and migration aspects, most of these research papers focus only on a limited number of factors. Moreover, the success factors that are explored are limited to various organisation aspects and mainly ignore the in-depth technical aspects. Hence, it is difficult to draw a holistic understanding of the success factors in cloud migration.

### 2.7.2 Cloud Migration CSFs and Saudi Arabia Higher Education

The use of cloud services in UK and European universities is growing dramatically in comparison with the Middle Eastern universities. The Middle East has just begun the initial phase in order to offer teaching through cloud computing (Weber, 2011; Odeh, Warwick and Cadenas, 2014). According to Odeh *et al.* (2014) the usage of cloud computing in higher education in the Middle East is in the early stages, unlike European universities, which are widely using cloud nowadays. Zabadi and Al-Alawi (2016) conducted a case study about e-learning in Saudi Arabia and mention technical and telecommunication infrastructure as the first challenge (Zabadi and Al-Alawi, 2016).

Alshwaier (2012) cites advantages of cost, efficiency, reliability, portability, flexibility and security in adopting cloud for e-learning in the Kingdom of Saudi Arabia (KSA) and indicated that cloud-based learning management system (LMS) can ease the teaching process and help in managing the growing number of students enrolling for higher education in KSA (Alshwaier, 2012). He also cites security, availability, vendor lock-in and unsolicited advertising as challenges of cloud-based education in KSA, but this study was not focused on finding a

framework based on challenges or CSFs. Any challenges and success measures, if understood soundly within the context of Saudi Arabian universities, are likely to increase the chances of a successful migration to the cloud. This study was mainly to show the advantages of cloud migration and give examples of cloud offerings for e-learning in KSA.

Albalawi (2007) carried out research on CSFs related to the implementation of web-based instruction by higher education faculty at three universities in the KSA. He cites support from top management and the attitude of instructors as among the CSF for implementation of web-based instruction in Saudi Arabia, apart from technological, performance and cultural factors. Since cloud computing is a part of the web, these factors also hold true for the cloud.

Aldayel et al. (2011) discuss the CSFs of ERP: enterprise resource planning systems implementation and outsourcing in higher education in Saudi Arabia. They conclude that the most important success factor is project management (Sugawara and Nikaido, 2014). Alfaadel et al. (2012) investigated the success and the failure of IT projects in Saudi Arabia, concluding that the most important factors that cause IT projects to fail in Saudi Arabia are poor planning, weak project management process, not enough resources allocated, office politics and, finally, the IT department and business users not speaking the same language. The most important CSFs to implement IT projects are: a clear statement of requirement; a competent project manager; top management support; organisational culture; and clear project goals.

Mansour (2013) conducted a case study on cloud adoption in the Islamic University of Gaza in Palestine (IUG). The author identifies CSFs such as top management support, compliance, physical location and security. However, the study was only on a single university in Palestine and the author did not consider many challenges such as interoperability, service availability and disaster recovery, or cultural issues such as privacy and the attitude of users. Alotaibi (2014) concludes that the perception, attitude and intention of Saudi people towards the adoption of cloud computing in Saudi Arabia is more important than technological factors such as security and scalability, which are common to all countries (Alotaibi, 2014).

There has been research into the CSFs for WBL, LMS, e-learning, ERP, ICT and virtual learning in Saudi universities (Albalawi, 2007; Asiri et al., 2012; Yamin, 2013). Some research has been conducted on Saudi higher education migrating to the cloud (Areshey, Alshwaier and Alshuwaier, 2012; Alamri and Qureshi, 2015; Tashkandi and Al-Jabri, 2015; Karim and Rampersad, 2017). However, none of these researchers have provided empirical investigation on the CSFs to migrate to cloud computing.

## 2.8 Chapter Summary

The quality of ICT services in Saudi Arabia is hindered by a lack of both good infrastructure and IT qualified members in universities (Alshayea, 2012; Alshetwi, 2014). The shortage of qualified IT personnel, coupled with rapidly increasing enrolment at Saudi universities, makes it imperative to enhance the provision of learning electronic services through cloud-based applications. However, it is important to be aware of the CSFs that facilitate the cloud migration process to avoid the failure of the migration project. The challenges could arise from both the characteristics of cloud computing itself, as well as from culture aspects of Saudi universities. From a cultural perspective, the successful migration to cloud services in Saudi Arabia's universities depends on the capabilities of top management and the deanship of IT to drive an organisational change actively through an official cloud migration plan. Existing research into cloud migration shows a lack of consideration of the area of CSFs. Few studies have considered the importance of the role that CSFs play in increasing the chances of success of a cloud migration project.

The critical review of the literature in this chapter reveals that most of the proposed DSS solutions for cloud migration projects focus either on applications migration level or on the best cloud service providers to meet organisations' requirements. The proposed solutions do not consider the internal preparedness (the CSFs') role in the migration process, especially in the context of higher education institutions.

Furthermore, there is a lack of research considering the identification and evaluation of both the challenges that hamper Saudi universities in migrating to the cloud and the CSFs that contribute to the success of the migration project.

# Chapter 3

# Cloud Migration Success Factors Framework

As introduced in the last chapter, there are several challenges that Saudi universities may face if they decide to migrate their ICT services to cloud-computing services. Some of these are challenges for universities the world over, but there are some that are specific to cultural aspects of Saudi universities context. Qualified IT staff, data outsourcing policies, Saudi education IT policies, technical support requirements, internet connectivity and lack of good bandwidth may affect the latency and performance of cloud-based services in this context (Alkhazim, 2003; Ercan, 2010).

Although the success of cloud migration projects is deemed important to all organisations, including those that intend to migrate to the cloud, few studies have addressed the role of CSFs in cloud-computing deployment (Garrison, Kim and Wakefield, 2012; Alkhlewi, Walters and Wills, 2015a, 2015b) and none has considered the Saudi education context. In this chapter, the detail of the construction process for the research initial proposed framework's CSFs is presented. This initial solution framework (SFCM1) comprises the success factors for cloud migration that were extracted from secondary data within the literature reviewed in Chapter 2, which covers various disciplines including cloud migration determinants and challenges, and WBL and ERP projects in Saudi higher education and elsewhere.

## 3.1 The Proposed Framework Construction

Frameworks are widely used in a number of IT fields pertaining to IT outsourcing and managing (Yusof et al., 2008; Sharp, Atkins and Kothari, 2011; Tarek and Ahmed, 2013), which have similar issues to cloud-computing migration. Considering the field of cloud computing in particular, a framework is widely used to investigate different cloud research topics such as SLA, decision-making, governance, adoption, security and migration issues (Veiga and Eloff, 2007; Alhamad, Dillon and Chang, 2010; Samanthula et al., 2015; Alhammadi, 2016; Alharthi et al., 2016).

There are variations in the definition for the term 'framework' in the literature. The definition is influenced by the context of the study. In the software development field, it is defined as *'A reusable design of all or part of a system that*

*is represented by a set of abstract classes and the way their instances interact'* (Johnson, 1997). From a business perspective, a framework is defined as *'A systematic set of relationships or a conceptual scheme, structure or system'* (Jung and Joo, 2011). The first two definitions are not similar, as the first describes the framework as set of classes while the latter describes it as set of relationships or concepts. However, in general a framework is defined as 'a basic structure underpinning a concept or system. It is a comprehensive outline, or skeleton of interlinked concepts which explain or supports a particular approach to a specific goal and helps as a guide that can be altered as needed by adding or deleting items' (Rodman, 1980).

Frameworks are widely used by researchers to provide guidance, communication and a clear description for decision-making. Using frameworks can reduce the time and cost of a project (Fayad and Schmidt, 1997; Jung and Joo, 2011). In this study, a framework is developed as a blueprint for investigating the CSFs that can facilitate the successful migration to cloud services by universities in Saudi Arabia. This study's framework comprises two conceptual domains, technological and organisational, each linked to set of relevant CSFs. These can be used by IT personnel, decision-makers and researchers to define and prioritise the tasks involved in preparing for cloud migration.

To establish a threshold of understanding of the framework concept's CSFs, it is defined in this study context as 'Those enablers that should be guaranteed by universities' IT deanships for successful migration of their traditional ICT educational services to cloud-based services'. These CSFs should be used to analyse the reasons behind the success or failure of cloud deployments in similar educational institutions. The framework construction went through four phases. The abstract of the framework's development four phases is depicted in Figure 3 1 and each development phase is elaborated below:

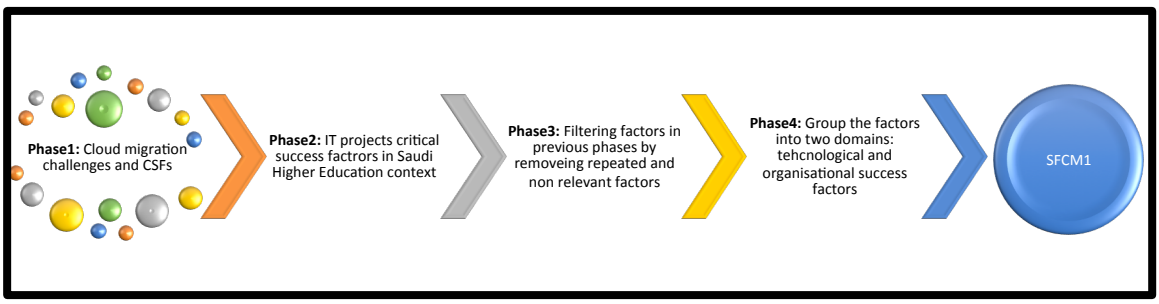


Figure 3-1: SFCM1 development process

### ❖ Phase 1: Identifying the challenges and CSFs of cloud migration

The first phase involved identifying and reviewing published papers, specifically those concerning the challenges and CSFs of cloud migration frameworks and

models both in general and in higher education institutions in particular, and refactoring those challenges as success factors. The rationale for refactoring is the lack of published work that investigates technological and organisational critical success factors for cloud migration. The challenges that organisations may face in cloud migration in a global context, as extracted from the literature, include the following:

- **Resultant cloud system complexity:** this issue can be refactored to include those such as ease of use, interoperability, compatibility, scalability and cultural attitude aspects (Wheeler and Waggener, 2009; Sultan, 2010; A. J. Mansour, 2013; Alkhater, Walters and Wills, 2015; Tashkandi and Al-Jabri, 2015).
- **Achieving reliability:** reliability issues can be addressed by capabilities such as gaining high uptime, better performance, minimal outages, disaster recovery plans and adequate network bandwidth (Albalawi, 2007; Wheeler and Waggener, 2009; Mathew, 2012; Truong *et al.*, 2012; Mansour, 2013; Tashkandi and Al-Jabri, 2015).
- **Promoting security:** by providing data access and good degrees of control, ensuring privacy and providing data protection though implementing various security controls to achieve the main systems security principles Confidentiality; Integrity; and Availability (CIA) (Wheeler and Waggener, 2009; Sultan, 2010; Weber, 2011; Alshwaier, 2012; Mansour, 2013; Odeh, Warwick and Cadenas, 2014; Alkhater, Walters and Wills, 2015).
- **Organisation readiness:** There are several studies highlighting the importance of managerial aspects for successful cloud migration projects which including factors such as management support, technology readiness, organisation size, SLA requirements, policy and legislation, project planning, and IT staff readiness (Wheeler and Waggener, 2009; Abdollahzadehgan *et al.*, 2013; Mansour, 2013; Alkhater, Walters and Wills, 2015; Alkhlewi, Walters and Wills, 2015a; Tashkandi and Al-Jabri, 2015).
- **Ensuring compliance with the Saudi regulations:** this can be achieved through an alignment os Saudi Ministry of Education policies and the cloud service provider (Albalawi, 2007; ALdayel, Aldayel and Al-Mudimigh, 2011; Alshwaier, 2012; Truong *et al.*, 2012; Alshetwi, 2014; Alkhater, Walters and Wills, 2015).

### ❖ Phase 2: Finding success factors for IT projects in Saudi Arabia's Higher Education

Due to the lack of research into CSFs related to cloud migration issues, the second phase of the framework's construction involved finding the CSFs of the deploying technologies (WBL and ERP) similar to cloud computing in the Saudi Arabia

universities context. This step aimed to understand the cultural aspects of IT projects in this context. The cultural success factors already reported in the literature pertaining to this context are elaborated below (Albalawi, 2007; Aldayel, Aldayel and Al-Mudimigh, 2011; Asiri et al., 2012):

- **Arabic language support:** Due to a decade-long effort to integrate Arabic language support in all corporate, government and private organisations, its integration into cloud services is deemed important as the legacy systems are highly likely to be working on the national language level already, for instance WBL systems.
- **Individual level factors:** Factors such as IT user and general user attitudes, peers support, and perceived ease of use play an important part in the migration process as people generally resist change. Therefore, assessing the measure of willingness and the overall attitude of the staff/users holds a pivotal importance in any technological migration process.
- **Organisation internal factors (Technology/Organisations readiness):** within organisational boundaries, CSFs include diverse issues such as top management commitment, ministerial policies, quality of education and delivery, and IT infrastructure issues such as internet quality and limited access to IT resources. These issues can play significant role in providing measures to assess the readiness of the organisation for cloud migration.

### ❖ Phase 3: Synthesis of the proposed CSFs in the SFCM1 framework

In Phase 3, the success factors identified in the previous two phases were synthesised and filtered. The two criteria applied to reach a decision to adopt the critical success factors in SFCM1 were: (a) if the factor is explicitly mentioned as critical and there is a consensus about its importance to the success of the cloud migration projects in most of the frameworks and the models in the literature; (b) if the factors only pertain to organisations' internal technical and managerial preparedness capabilities (practices or assets). Thus, individuals and external environmental context-related factors were disregarded. The duplicated factors were removed, and the overlapping factors were merged and refactored. For instance, 'internet quality' and network bandwidth are duplicates, and user attitude, staff readiness, acceptance and perceived ease of use overlapped and were grouped as a 'User awareness' factor.

Irrelevant factors from Phase 2 were removed, as some factors such as quality of education, limited access to IT resource and peer support were deemed not relevant to the objectives of this research, as the scope of the research is investigating the internal organisation-level factors that play an important role in the successful migration to the cloud while individuals' influencing factors and

environmental external factors are more related to a step prior to the migration; that is, the adoption of the technology. In addition, Arabic language support was not adopted due to the fact that all the IT personnel working in the IT deanship in the Saudi universities are familiar with the English language and the formal language in the working environment is English. Hence, Arabic language support was removed. A summary of the final chosen success factors in the SFCM1 framework and the studies sources derived from them is described in Table 3 1.

Table 3-1: Summary of identified CSFs

| Domain | Technological Success Factors | | | | | Organizational Success Factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Success Factor / Study Sources | Reliability | Security & Privacy | Network Bandwidth | Disaster Recovery | Interoperability | Management Support | Users Awareness | Ministry of Education policies | Degree of control | SLA-Requirements |
| (Alkhlewi, Walters and Wills, 2015a) | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | | |
| (Mansour, 2013) | | ✓ | | | ✓ | ✓ | ✓ | | ✓ | |
| (Sultan, 2010) | ✓ | ✓ | ✓ | | ✓ | | | ✓ | ✓ | ✓ |
| (Tashkandi and Al-Jabri, 2015) | | ✓ | | ✓ | ✓ | ✓ | | ✓ | | ✓ |
| (Truong *et al.*, 2012) | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | |
| (Wheeler and Waggener, 2009) | ✓ | ✓ | | ✓ | | | ✓ | ✓ | | ✓ |
| (Albalawi, 2007) | | | ✓ | | | | ✓ | ✓ | | |
| (ALdayel, Aldayel and Al-Mudimigh, 2011) | | | | | | ✓ | ✓ | ✓ | | |
| (Alshwaier, 2012) | | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | |
| (Alkhater, Walters and Wills, 2015) | ✓ | ✓ | | | ✓ | ✓ | | ✓ | | |
| (Alsanea and Barth, 2014) | | ✓ | | | | | ✓ | | ✓ | ✓ |
| (Odeh, Warwick and Cadenas, 2014) | | ✓ | | | | ✓ | | | ✓ | ✓ |
| (Weber, 2011) | ✓ | ✓ | ✓ | | | | ✓ | | ✓ | ✓ |
| (Abdollahzadehgan *et al.*, 2013) | | | | | ✓ | ✓ | ✓ | | | |

### ❖ Phase 4: Grouping the identified success factors to related domains

The final phase in the development of the framework was the grouping phase. The resultant factors from earlier phases were found to be related either to the internal infrastructure and technology aspects of the organisation or human and organisation managerial factors. The SFCM1's success factors were grouped into technological and organisational, as the research objectives consider the key enablers or capabilities in the organisation to mitigate the risks of cloud migration

project failure and increase the likelihood of success. A confirmatory study was carried out to review and confirm the CSFs in SFCM1 framework by interviewing IT experts and surveying IT practitioners in Saudi universities. The details of the confirmatory study for the SFCM2 framework are discussed in Chapter 5.

## 3.2 Initial Success Factors Cloud Migration (SFCM1) Framework

The proposed framework comprises 10 critical success factors, as shown in Figure 3 2. These represent the technological and organisational aspects that can have a facilitating role for the cloud migration project in the Saudi universities context. A discussion about the two domains of the framework and the associated CSFs follows.

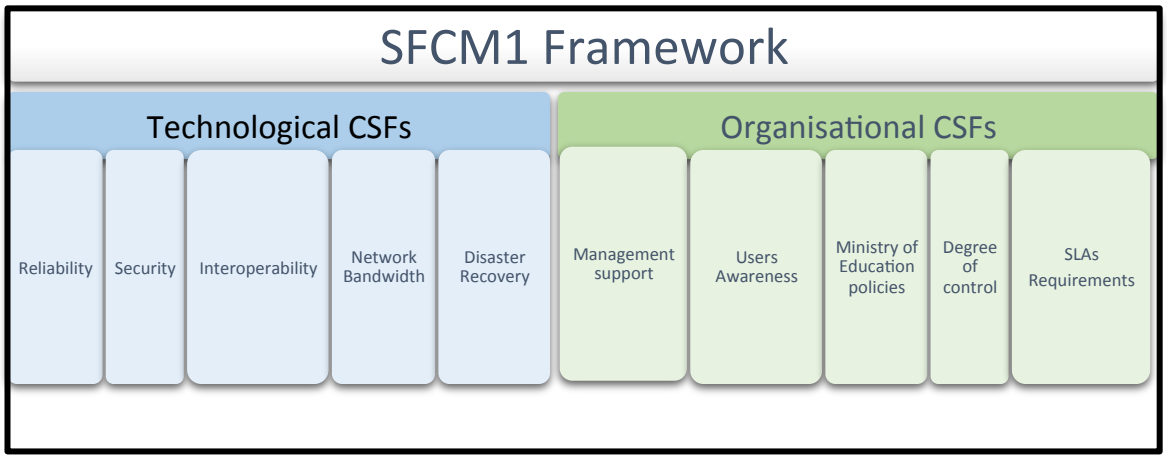


Figure 3-2: Initial CSFs Framework for Cloud migration in Saudi universities

### 3.2.1 Technological CSFs

Technological success factors are related to technical capabilities and the cloud characteristics which determine the quality of service delivered (Garrison, Kim and Wakefield, 2012; Alkhater, Walters and Wills, 2015). There are five success factors underpinning the technological domain:

- **Interoperability**

A universal set of standards and interfaces has not yet been defined for cloud based services, resulting in a significant risk of vendor lock-in. Higher education institutions should make sure that Cloud-based IT solutions must be interoperable and compatible between different providers; 24/7 access to secure, reliable networks; and the ability to create, deliver, and share content campus-wide on any number of devices (Sultan, 2010; Alshwaier, 2012; Truong *et al.*, 2012; Abdollahzadehgan *et al.*, 2013; Mansour, 2013; Alkhater, Walters and Wills, 2015; Tashkandi and Al-Jabri, 2015).

- **Reliability**

The University cloud-based services should be reliable and continuously available through providing redundant services, but the possibility still exists that the system could crash and leave clients with no way to access their saved data. Many existing cloud infrastructures leverage commodity hardware that is known to fail unexpectedly. A loss of Internet connectivity anywhere between a university customer and their cloud provider's network will cause interruptions of varying severity. It is important for the service to be reliable if it is available. So, without availability, reliability cannot be achieved. A cloud service should first be available in order to be reliable (Wheeler and Waggener, 2009; Sultan, 2010; Weber, 2011; Truong *et al.*, 2012; Alkhater, Walters and Wills, 2015; Alkhlewi, Walters and Wills, 2015a; Tashkandi and Al-Jabri, 2015)

- **Security and Privacy**

Privacy and security are the top concerns for higher educational institutions planning to adopt cloud computing, due to the migration of sensitive data such as students' records, Researchers' Patents and intellectual properties beyond the campus walls, hence the crucial importance of security and information privacy in university IT environment (Sultan, 2010; Weber, 2011; Alshwaier, 2012; Truong *et al.*, 2012; Mansour, 2013; Alsanea and Barth, 2014; Odeh, Warwick and Cadenas, 2014; Alkhater, Walters and Wills, 2015; Alkhlewi, Walters and Wills, 2015b; Tashkandi and Al-Jabri, 2015).

- **Network Bandwidth**

Cloud computing is a stateless system, as is the Internet in general. For communication to survive on a distributed system, it is necessarily unidirectional in nature. Most of remote requests used in the cloud is through HTTP messages such as PUT and GET. The HTTP requests reach the provider and the service provider sends a response. Low bandwidth would increase the latency of communications, and the service would become very slow if bandwidth is not increased. Therefore, Saudi universities should increase Internet bandwidth in order to provide good cloud-base services to their stakeholders (Albalawi, 2007; Sultan, 2010; Weber, 2011; Alshwaier, 2012; Mathew, 2012; Truong *et al.*, 2012).

- **Disaster Recovery**

Saudi universities should ensure data recovery and business continuity back up plans, particularly regarding what they are responsible for during a disaster affecting their data centres. Universities have indirect administrative responsibility for the security of their data and applications, and are accountable for data breaches and disaster recovery (Wheeler and Waggener, 2009; Alshwaier, 2012;

Truong *et al.*, 2012; Alkhlewi, Walters and Wills, 2015b; Tashkandi and Al-Jabri, 2015)

### 3.2.2 Organizational CSFs

Organisational success factors are related to the university's resources, human culture and operational roles, and the best practices to migrate to the cloud services (Garrison, Kim and Wakefield, 2012; Abdollahzadehgan *et al.*, 2013; Alkhater, Walters and Wills, 2015). There are five identified success factors pertaining to this domain:

- **Top Management Support**

From a strategic perspective, the successful implementation of cloud solutions in Saudi Arabia depends on the capabilities of top leadership or management to drive the change from traditional deployment to cloud adoption through an official pro-cloud strategy. Decision-makers' awareness and consensus is vital. Their support will ensure what cloud services are needed and what type of cloud deployment is best for higher education settings.

In order to do that, the decision-makers have to understand the benefits of cloud-based services, the value that they can add to the educational services and how to migrate to a cloud-computing environment (Aldayel, Aldayel and Al-Mudimigh, 2011; Abdollahzadehgan et al., 2013; Mansour, 2013; Odeh, Warwick and Cadenas, 2014; Alkhater, Walters and Wills, 2015; Alkhlewi, Walters and Wills, 2015b; Tashkandi and Al-Jabri, 2015).

- **Ministry of Education (MOE) Policies**

Since cloud computing is relatively new IT paradigm, it will require changes to be made to MOE policies and regulations, and to comply with legislation by Saudi government to ensure the safety of stakeholders' information. Saudi universities need to improve data policies in order to protect their sensitive information. This involves developing institution wide cloud policies to help the institutions to select the right sourcing and solutions that comply with the regulations in Saudi Arabia (Albalawi, 2007; Sultan, 2010; ALdayel, Aldayel and Al-Mudimigh, 2011; Alshwaier, 2012; Truong et al., 2012; Alkhater, Walters and Wills, 2015; Alkhlewi, Walters and Wills, 2015b; Tashkandi and Al-Jabri, 2015).

- **Users Awareness**

The successful implementation of any new IT paradigm that requires a proper plan to educate and increase the awareness of the stakeholders dealing with the technology and how to develop cloud solutions to serve educational entities. Therefore, Saudi university IT departments should provide their IT staff with training sessions on how to run cloud-based services and then introduce the services to their stakeholders (academics and students), and provide them with a

guide to using them properly (Albalawi, 2007; Wheeler and Waggener, 2009; Aldayel, Aldayel and Al-Mudimigh, 2011; Weber, 2011; Truong et al., 2012; Abdollahzadehgan et al., 2013; Mansour, 2013; Alsanea and Barth, 2014; Alkhlewi, Walters and Wills, 2015b).

- SLA Requirements

Saudi universities need to be able to ensure that the service provider will continue to be there, even in the face of a changing market. SLAs are the contract between the users of cloud services and the provider, and contain the expected up-time and performance of those services. Universities should consider those measurements and prepare a list of customised requirements for each service that they use, and they need to collect each department's requirements in order to indicate these in the SLA to cover the end-user experience and the customers' operations (Wheeler and Waggener, 2009; Sultan, 2010; Alsanea and Barth, 2014; Odeh, Warwick and Cadenas, 2014; Tashkandi and Al-Jabri, 2015).

- Degree of Control

The amount of control that the user has over the cloud environment varies greatly. In a traditional IT environment, the consumer has full control over the services accessed. But the same is not true for the cloud services. For that reason, there is loss of control when universities migrate to the cloud, and it is the duty of university IT seniors or management to make sure that the control is given to the right provider or to decide what should be under their control and what can be migrated (Sultan, 2010; Weber, 2011; Mathew, 2012; Alsanea and Barth, 2014; Odeh, Warwick and Cadenas, 2014).

The abovementioned CSFs are derived from the literature review and aimed at extracting the most relevant CSFs to Saudi universities. Some of these factors such as Security and Privacy is bound to regulatory compliance unique to Saudi expert councils which release decrees to prevent cloud deployment beyond national boundaries. The second unique aspect is that of the network bandwidth which, based on the in-house service position, is likely to lead to deficiencies. Therefore, this aspect will have to be handled at the local level and hence is deemed to be unique to the Saudi context. As the Arabic language is the primarily language of communication, technical support must have capabilities to address their clients' service requirements thereby making this a unique success factor. Further discussion of the unique and general CSFs similar to other countries and applicable to Saudi context are discussed in Chapter 5.

## 3.3 Chapter Summary

In this chapter, a discussion of the development phases and methods used to identify the CSFs pertaining to the context of Saudi universities. This construction process led to proposing the research initial framework SFCM1 that comprises of two CSFs domains: technological and organisational. The proposed SFCM1 framework in this chapter is the first contribution of this research and was confirmed using a mixed-method confirmatory study (explained in Chapter 5) with IT experts and specialists working in Saudi Arabian universities.

# Chapter 4

# Research Methodology

In earlier chapters, the emphasis was on reviewing the literature related to cloud migration CSFs in the context of Saudi universities and the initial proposed SFCM1 framework. This chapter comprises the research methods used, as outlined in Figure 4-1. Section 4.1 provides an overview of the research questions, sub-research questions and underlying methods to address these questions. Section 4.2 contains an overview of various methods in general in the context of this research. Section 4.3 presents a discussion of the research methods employed in confirming the initial SFCM1 framework. Finally, section 4.4 discusses the research methods used in the evaluation case studies.

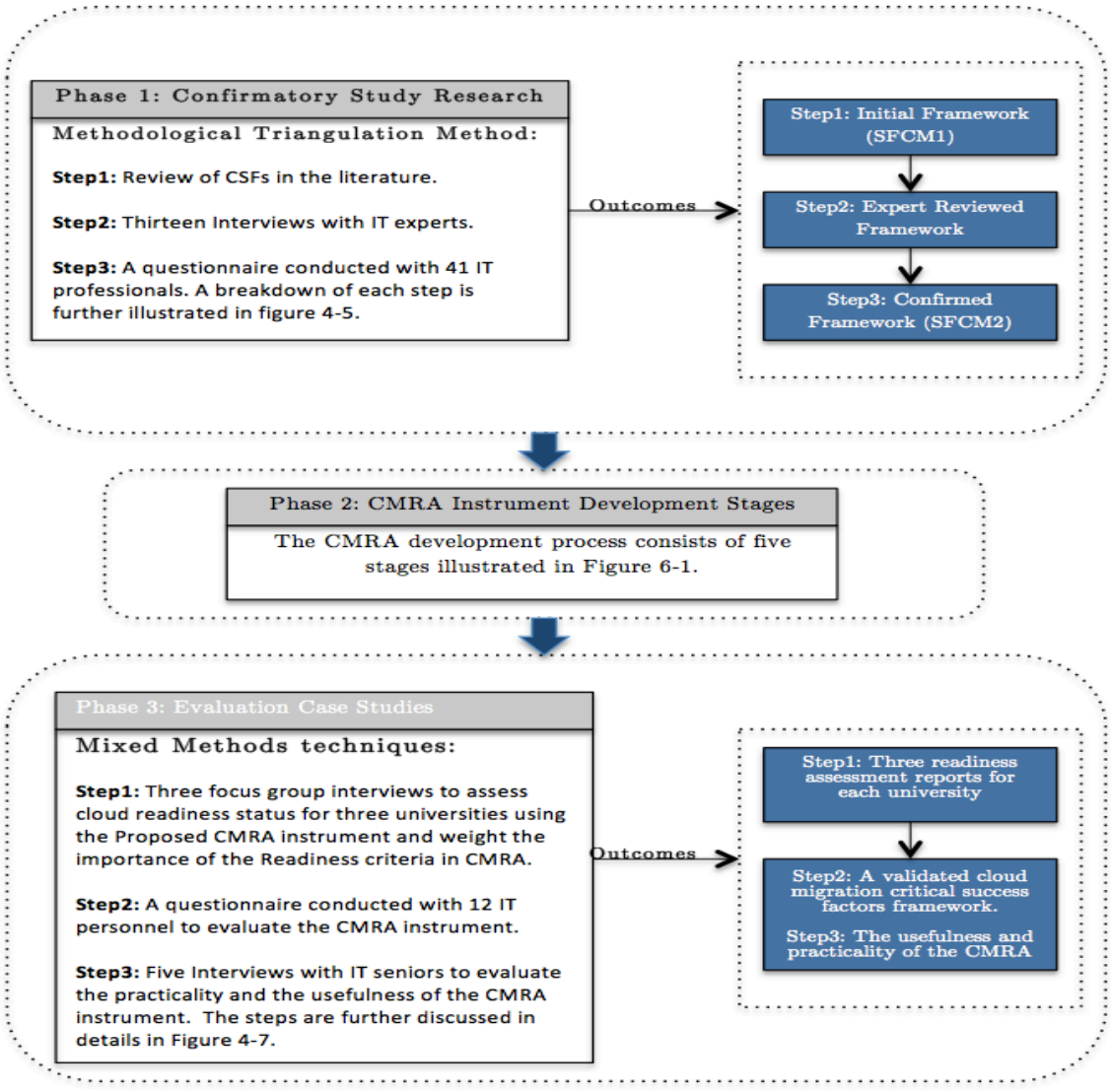

Figure 4-1: Research Methods Used in this Thesis

## 4.1 Overview of Research Questions

The research methods were conducted to address the two main research questions RQ1 and RQ2 and their sub-research questions. Each research question and related sub-research questions, and the methods for addressing the sub-research questions, are shown in Table 4-1.

Table 4-1: Map of Research methods used to address research questions

| Research Question | Sub-research Question | Research Methods for addressing sub-research questions |
|---|---|---|
| **RQ1: What is the appropriate cloud migration success factors framework for Saudi Universities?** | RQ1.1: What are the challenges of migrating university's ICT to cloud paradigm? | - Review of frameworks and secondary research (Chapter 2)<br>- Semi-structured interviews with 13 IT experts (section 4.3.2). |
| | RQ1.2 What are the critical success factors for cloud migration in Saudi Arabian universities? | - Review of frameworks and secondary research (Chapter 2)<br>- Semi-structured interviews with 13 IT experts (section 4.3.2).<br>- A questionnaire distributed to 41 IT professionals (section 4.3.4) |
| **RQ2: Based on the confirmed framework, what is the appropriate instrument to measure the readiness status of Saudi Arabian universities for cloud migration?** | RQ2.1: What are the readiness assessment criteria and their measuring items for cloud migration? | - Review of frameworks and secondary research (Chapter 2)<br>- Using Goal-Question-Metrics approach and Process assessment model (sections 6.1.2 and 6.1.3).<br>- Semi-structured interviews with six IT cloud experts to validate the content of the instrument (Section 6.2) |
| | RQ2.2: Based on the Saudi university requirements, what is the importance/priority of each the readiness criterion in the proposed instrument? | - A questionnaire with 12 IT professionals working in the IT deanship in three Saudi universities (section 6.3) |
| | RQ2.3: How good is the functionality and practicality of CMRA instrument? | - Three case studies (section 4.4).<br>- An evaluation survey conducted on the IT team members (section 4.4.3).<br>- Five semi-structured interviews with IT senior managers (section 4.4). |

## 4.2 Overview of Research Methods

### 4.2.1 Qualitative methods

Qualitative research is an investigative methodology aimed primarily at exploring, analysing and interpreting data where it is not possible to derive any meaningful understanding by numbers (Creswell, 2013). The technique is exploratory in a sense that it helps a researcher to understand an ongoing area of research where a

complete understanding has still not been achieved (Thomson, 2003). In qualitative analysis, there are four main categories of investigation including observations, interviews, focus groups, documents and audio-visual resources. However, interviews are the most common type of medium used to extract information from subjects (Rogers, Sharp and Preece, 2011).

Interviews are further categorised into open-ended or unstructured, structured and semi-structured, based upon the level of control that the interviewer wants to have over the interview. The degree of control is set by an interviewer and is determined by the set of questions prepared. Qualitative research does produce a large amount of information and it is often difficult to assess which parts are relevant to the study itself (Creswell, 1998). Unstructured interviews are mainly driven by experts who support the hermeneutic or positivist paradigm, which requires textual information that also might be used as formal guide for semi-structured interviews (Bernard, 2006, p.158).

Since structured interviews are mainly used to identify identical aspects from all the interviewees, the questions are structured as concrete guidelines already set by the interviewer. This type may include pile sorting, frame elicitation, triad sorting and rating activities to give more meaning to the information (Creswell, 2013).

In semi-structured interviews, the questions are already prepared, as in the structured interviews. However, they are reasonably open to allow improvisation, often termed as 'interview in-depth' (Myers and Newman, 2007). The semi-structured interviews must be well designed in order to extract information from the respondents. Focus group interviews are usually used as a convenient and quick method to collect data from similar participants simultaneously; this method is useful for exploring participants' experiences and knowledge. It allows the grouped participants to talk to one another and comment on each other's point of views (Kitzinger, 1995; Krueger and Casey, 2001).

### 4.2.2 Quantitative methods

The information extracted in quantitative research can be represented via numbers. The method is commonly used where rudimentary research has already been undertaken and further confirmation of the underlying theory has to be established (Recker, 2012). In this type of research method, numerical data can create useful statistics, as a large number of participants can be surveyed. The data gathered is analysed by various statistical tests. Therefore, the result is more generalisable to a population (Thomas, 2003, p.66).

Most research carried out in this domain is based on questionnaires. Questionnaires are used to mainly collect two principle types of information, namely factual and opinion-based. Facts, in this case, are items of information

about which the respondents have knowledge, whereas opinions are based on individual attitudes or preferences (Thomas, 2003, p.66).

Questionnaires can have either a structured or unstructured format. The former is easier to capture and analyse, and can further be categorised into dichotomous, nominal, ordinal, scale and continuous. Dichotomous is a two-choice response type, which can be a yes/no response. Nominal and ordinal types contain more than two choices, with the latter being ordered. The interval-level response type allows a choice from a five or more point scale such as a Likert scale. The continuous response type allows users to enter open-ended information such as text in a blank space (Jackson, 2012, p.163).

### 4.2.3 Mixed methods

The qualitative and quantitative methods are often criticised for weaknesses, which has led to researchers adopting a hybrid or mixed approach (Recker, 2012). The explicit combination leads to helping to answer questions that cannot solely be addressed merely by one of the two methods. For instance, 'Does security and extensibility both provide an ease of cloud migration in private cloud systems?' is a mixed-method question as it not only requires a response about two (presumably) success factors that represent a quantity (on a Likert scale) but also seeks qualitative information on the measure of ease of migration (Creswell and Plano Clark, 2011, p.13). Mixed methods can be used via five major techniques (Hesse-Biber and Johnson, 2015):

- Triangulation
- Complementary
- Initiation
- Development
- Expansion

Triangulation refers to two or more methods being employed to analyse a problem, and can be used for any purpose including study finding validation, generalisation and gaining a better knowledge of the research problem at hand. The technique can further be divided into four main forms (Polit and Beck, 2008, p.543):

- **Data triangulation:** Involves multiple resources which are used to validate conclusions
- **Investigator triangulation:** Involves data being collected and analysed by various research resources to eliminate subjective impacts from individual investigators
- **Theoretical triangulation:** Used to investigate data from different theoretical perspectives

- **Methodological triangulation:** Used to employ various methods on the same data to cross-validate and compare the findings
- **Time triangulation:** Involves using data from various points in time to assess reliability

## 4.3 Research methods employed in the confirmatory study

As the baseline nature of the research objectives of this study focused mainly on data collected from individuals working in various IT deanships, methodological triangulation was deemed to be the most appropriate method to cross-confirm the initially proposed framework (**SFCM1**) via different techniques.

### 4.3.1 Triangulation:

The research methodology in this study was based on the triangulation method illustrated by Denzin (1973). It is shown in Figure 4.2, and is based on three steps: the first is a literature review; the second is qualitative expert interviews to review the proposed framework; and the third is a quantitative survey to confirm the reviewed framework by the IT experts.

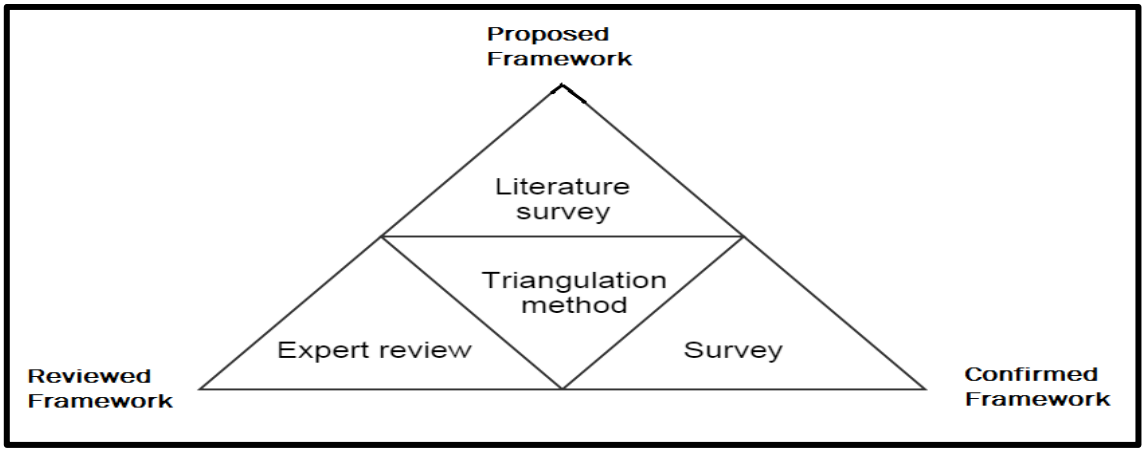


Figure 4-2: Triangulation confirmation for SFCM1 (Denzin, 1973)

### 4.3.2 Expert interview design and trial

Expert interview or review is a method of collecting the viewpoint of an individual who is an expert and has broad knowledge of the study subject. In this kind of interview, the experts are given a set of prearranged questions, whether using qualitative, quantitative or mixed methods. The questions may be related to confirming a framework, asking for suggestions about some points linked to the research study or related to the field of the study (Tessmer, 1993). The benefit of interviewing experts is that the researcher can obtain information and knowledge about the study from respondents who have experience in the field rather than from novices. However, this kind of review can be difficult and expensive to conduct (Tessmer, 1993). The expert interviews in this study involved semi-

structured interviews and discussions with experts from various IT departments in Saudi universities to improve and confirm the initial framework. This step was conducted by interviewing 13 IT experts from three Saudi Arabian universities, namely King Abdul Aziz, Jeddah and Taif universities. The experts in this study are those people who have worked on university IT projects for five years or more and projects managers in the IT departments of the universities.

Prior to the interview, each expert was asked to read the participant information sheet and sign the consent form. Qualitative studies in expert sampling usually depend on their knowledge in the area being studied (Bhattachejee, 2012). In this kind of sampling, the sample size is determined by the point at which no new knowledge is being gathered, and in this study, this was reached by 13 interviews (Guest, 2006).

Table 4-2: Expert Interviewees Profiles

| Participants | Position | Experience | Justification |
|---|---|---|---|
| P1 | System Administrator | 5+ years | Already using IaaS on a private in-house host |
| P2 | System Analyst | 5+ years | Already using IaaS on a private in-house host |
| P3 | Lecturer – IT Deanship | 5+ years | Already using IaaS on a private in-house host |
| P4 | Vice President of the Networking Department | 15+ years | Already using IaaS on a private in-house host |
| P5 | Head of Servers Department | 17+ years | Already using IaaS on a private in-house host |
| P6 | Network Security Engineer | 10+ years | No cloud computing experience but participate in many IT projects |
| P7 | Head of Internet Department | 6 years | No cloud computing experience but participate in many IT projects |
| P8 | Networks Department Manager | 8 years | No direct experience in cloud but overlook many IT projects |
| P9 | Assistant Professor – Admin of IT Services | 7 years | No directly working on the cloud but supervised many IT projects and member |
| P10 | System Admin | 6 years | No direct cloud experience but worked as an IT administrator in a general capacity |
| P11 | Data Analyst | 7 years | No cloud exposure but worked as a Data Analyst in a university environment |
| P12 | Head of Networks Department | 13 years | No experience in the cloud but directed the entire IT network infrastructure in a university |
| P13 | Associate Professor | 11 years | A certified expert a cloud-related field who believes that cloud migration is the way to go in the end. |

The interviewees were taken from the IT deanship of these universities and were interviewed over three weeks. An iPhone recorded the interviews using the Recorder application. The files recorded were then sent to the system desktop and the NVivo-11 package was used to analyse the information saved it. The semi-structured interviews were used to discover individual attitudes towards the problem at hand and to obtain an in-depth exploration of their experience in order to ascertain the existing cloud migration status in their respective universities and review various CSFs leading to successful migration to the cloud-computing paradigm. As the participants were deemed to be experts, they were expected to

add/modify/delete factors that may contribute to extending and updating the initially proposed critical success factor framework (SFCM1).

The interview questions were designed so that section 1 focused on exploring the current status of the cloud in Saudi universities, section 2 technological CSFs, while section 3, organisational CSFs, focused on reviewing the importance of these two CSFs. Another question focused on extracting user recommendations about any additional CSFs that could potentially lead to a better migration to the cloud. Moreover, the respondents were queried about various types of cloud models that were more suitable for the socio-cultural environment of Saudi universities. The interview questions are attached in Appendix A.

After the development of the expert interview questions and prior to conducting the actual interviews, the questions were trialled (pilot testing). A pilot provides researchers with the opportunity to use the interview instrument in its intended settings (Leeuw, Hox and Dillman, 2008). The trial sessions for the expert interview questions in this research were conducted with 11 participants with various IT expertise working in Saudi universities, and six of them are also computer science researchers at the University of Southampton. The purpose of these trial sessions was to ensure that the interview questions accurately represented the research context and that they were understandable. The participants' comments and suggestions were addressed and the questions were amended accordingly.

### 4.3.3 Expert interview qualitative analysis

The thematic analysis was used to assess, classify and report various themes within the raw interview data. These themes identify various patterns hidden within the collected representing details of the phenomenon. The method is therefore used as a way to organise and describe a corpus of meaningful data and to assist researchers in capturing critical information about their research questions (Aronson, 1994).

In the context of thematic analysis, a theme characterises critical information about qualitative data with regards to the research question. With qualitative data, themes of identification can be either inductive or theoretical thematic analysis. In the inductive approach, the identified themes have little relation to the questions asked during the interviews, as they are data driven. However, in theoretical thematic analysis (a theory-driven or analyst-driven analysis) more details are provided of some aspects of the data, but not all (Braun and Clarke, 2006). Since the aim of this study was mainly to confirm the identified CSFs in the framework, theory-driven analysis was adopted to analyse the interview data to capture participants' opinions of the framework, domains and CSFs. As the interview questions were focused on cloud migration CSFs, the codes were the CSFs.

To analyse the qualitative data, Nvivo-11 software was used to theme interviews' raw data. Each success factor was given a node and each node had its characteristics. The characteristics were clustered into three categories: Yes; No; and Uncertain. The next step was to code and allocate information from the transcript to the related nodes. The stages conducted during the thematic analysis are illustrated in Figure 4-3.

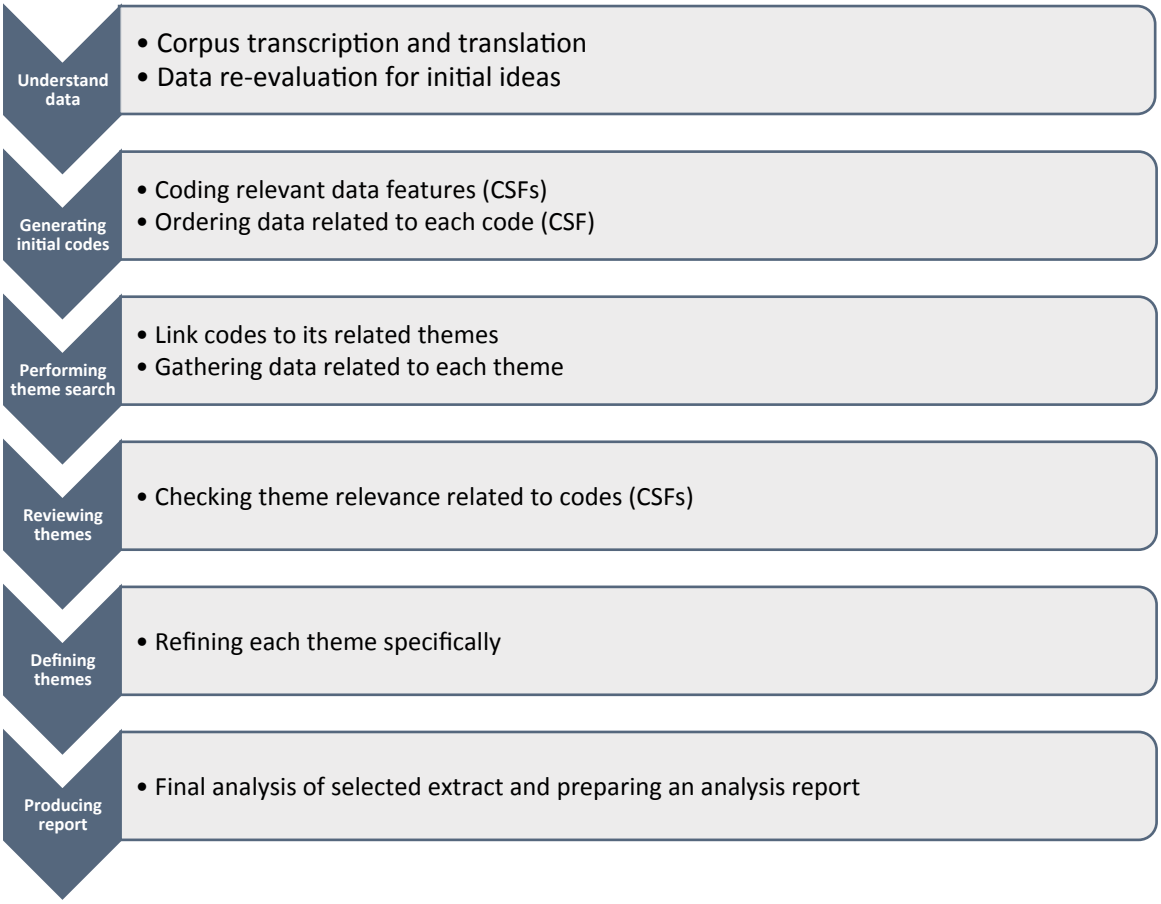


Figure 4-3: Thematic analysis phases (Braun and Clarke, 2006)

### 4.3.4 IT questionnaire design

An online questionnaire was designed on the basis of the outcome of the expert review in order to confirm the reviewed framework and make generalisations from a sample of the whole population. The questionnaire was distributed to confirm and quantify the findings from qualitative research. The participants in this survey were IT specialists working for university IT projects with a minimum of two years' experience.

The questionnaire was used to capture undetected data such as participants' opinions and unobservable large population data. The questionnaire allowed participants to reply at their own convenience (Bhattachejee, 2012).

### ❖ Online IT Questionnaire Content

The questionnaire was developed over the iSurvey[1] web portal and was based on three sections as follows:

- Demographic information and cloud background questions
- Technological success factors
- Organisational success factors

The first set was multiple choice and the remaining two were based on a 5-point Likert scale with '5' representing strong agreement (Strongly Agree) and '1' representing strong disagreement (Strongly disagree) (Likert, 1932). The adoption of short scale such a 5-points Likert scale is desirable in cases where absolute decision is required (Foddy, 1994). Therefore, the scale was deemed appropriate as the aim of this exploratory study is to investigate the IT experts' decision about the importance of the proposed CSFs. Similar to the interviews, the online questionnaires were distributed in Saudi universities to anyone with two years or more of experience of IT deanships (See the survey questions in Appendix B).

### ❖ Online IT Questionnaire Trial

The online questionnaire was trialled to explore whether the participants understood each question in the questionnaire or whether it should be edited. In addition, a trial of the questionnaire allows the researcher to discover if the participants face any difficulties in following the instructions or can easily complete it. According to Leeuw, Hox and Dillman (2008), the questionnaire pilot test minimum sample size is 10 respondents, and 11 respondents participated in the pilot test, with various roles including IT project managers, IT practitioners in Saudi university IT departments and computer science researchers at the University of Southampton.

### ❖ Minimum Sample Size Calculation

In quantitative research, calculating random sample size is usually involving involves mathematically preselected parameters. Two types of errors are considered when calculating the minimum sample size. The larger the sample size, the less these two errors can be occurred (Banerjee et al., 2009). The first type is a type I errors ($\alpha$), must be considered and by convention is set to 0.05 for 95% confidence. The second type is error II ($\beta$) and the power (1-$\beta$), which was set to 0.9 for 10% of missing association. To determine the minimum sample size for the survey participants, G* Power software was used and the calculation of t-test was

[1] https://www.isurvey.soton.ac.uk

performed to discover the difference in means form constant. The error must be considered for the first kind ( $\alpha$ ), the second kind ( $\beta$ ) and the power (1- $\beta$ ).

The first, also known as the 'error of the first kind', is when the null hypothesis is true but is rejected, whereas the latter 'error of the second kind' is when the null hypothesis is false but incorrectly fails to be rejected. The effect size is (d=0.8), because exploratory studies usually set at large effect size (Cohen, 1992). The minimum sample size that resulted from the test was 23, as displayed in Figure 4-4.

This minimum sample size was exceeded, as the questionnaire was distributed to 52 respondents working in Saudi universities by contacting them through their university emails addresses, and 41 individuals completely responded in full; s and some of the rest started the questionnaire, but did not complete finish it.

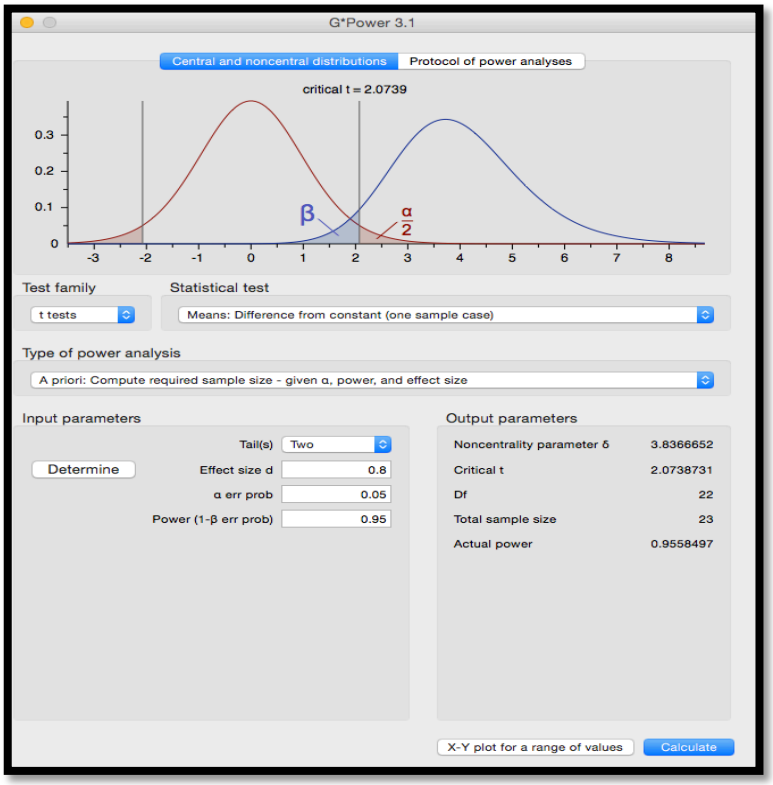


Figure 4-4: G*Power calculation Snapshot

### 4.3.5 Quantitative data analysis

The data was analysed both for its reliability and robustness. For its reliability, several psychometric tests have been developed, and with Cronbach's alpha being is one of them. The procedure in this method uses all the variance and covariance information of the data to provide a unique estimate of its reliability (Zeller and Carmines, 1980, p.56). Once the data is deemed reliable, it must still be compared against a 'gold standard' which is generally a hypothesis made in at the beginning of research. The one-sample t-test is a technique often used to compare the data gathered against an expected outcome. For instance, the user input gathered in

this study from a Likert scale is likely to be of a significant nature for any factor, if compared against a value higher than the neutral Likert number, which is '3.5' on a scale of 1 to 5, with 5 representing a strong user agreement.

In the current context, the typical hypotheses must be measured against a confidence level of 95% with the accepted error rate of $\alpha$ of 5% allowed as 0.05. Therefore, the null hypothesis and the relevant alternative hypothesis can be described as follows:

($\boldsymbol{H_0}$: The mean value of a factor is lower than or equal to the hypothesised value of 3.5)

($\boldsymbol{H_1}$: The mean value of a factor is greater than the hypothesised value of 3.5)

### 4.3.6 Ethics approval

Before interviewing the IT experts or distributing the questionnaire to participants, it needed to be planned to meet the ethical requirements of the research. Ethical approval was sought and granted by the University of Southampton's ethics committee, application **ERGO/FPSE/15707.** A summary of the methods in this confirmatory study is in Figure 4-5.

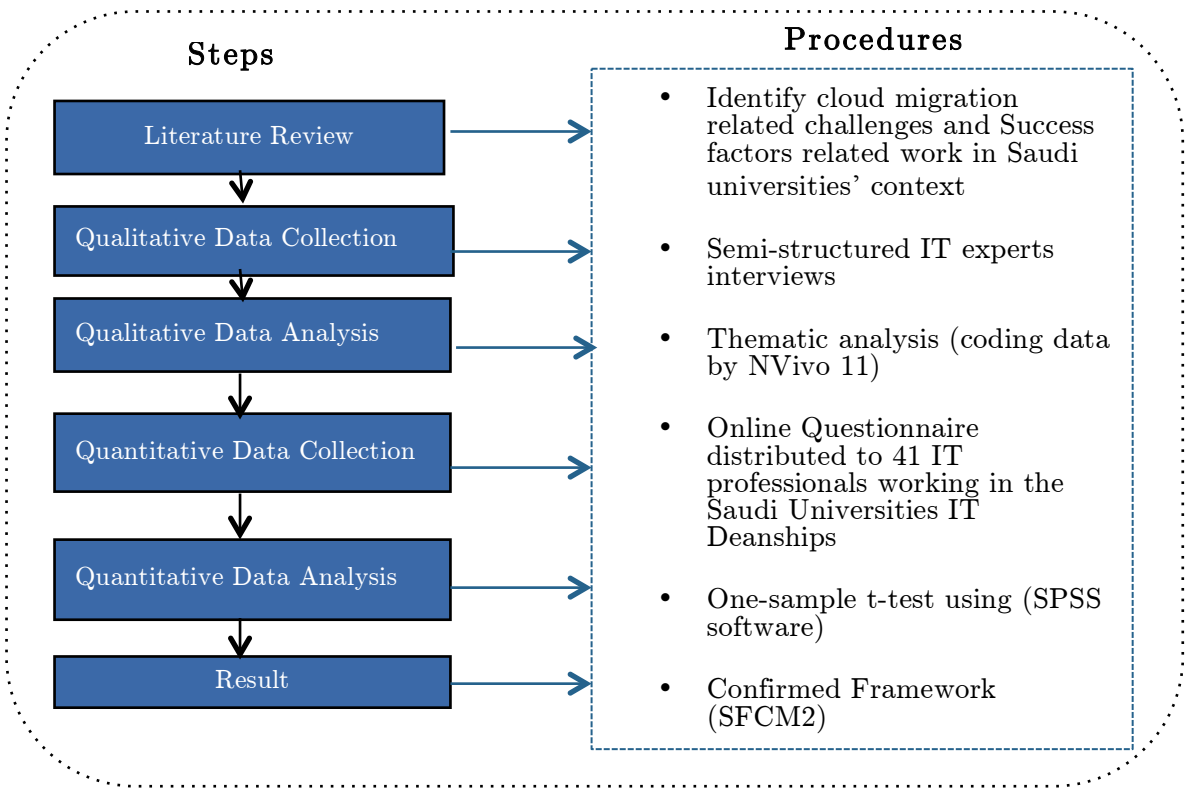


Figure 4-5: Research Methods Used in the Confirmatory Study

## 4.4 Research methods employed in the Case Studies

Case studies are generally used to validate a specific study, methodology, design or principle by its application to a larger context. Hence, a case study can be defined as an empirical method aimed at investigating contemporary phenomena undertaken as a research strategy, while stressing the use of multiple sources of evidence. Benbasat et al. (1987) adopt a more specific approach, mentioning information gathering from fewer entities such as people, groups and organisations and an absence of experimental control (Benbasat, Goldstein and Mead, 1987). Three major research methodologies are widely used in conducting case studies:

- Experiments, or controlled experiments are characterised by manipulating one variable in relation to another variable where various subjects are assigned to random treatments.
- Action research purposefully focuses on influencing or changing some aspect of whatever the aim of research may be and hence is suitable for a case study.
- A survey comprises drawing a collection of standardised information from a specific population or sample generally by means of a questionnaire or interview. This was the selected methodology in this research.

Case study designs are similar for any type of empirical studies, as proposed by Kitchenham, Pickard and Pfleeger (1995) and Kitchenham et al. (2002). A case study promotes a flexible design approach and may contain a substantial amount of iteration in its steps (Andersson and Runeson, 2007).

For instance, in a situation where not enough data is available, an additional collection can be performed. However, the primary restriction to case study design flexibility is that it should have a specific and established goal from the start (Runeson and Höst, 2009). A typical case study contains the phases outlined in Figure 4-6.

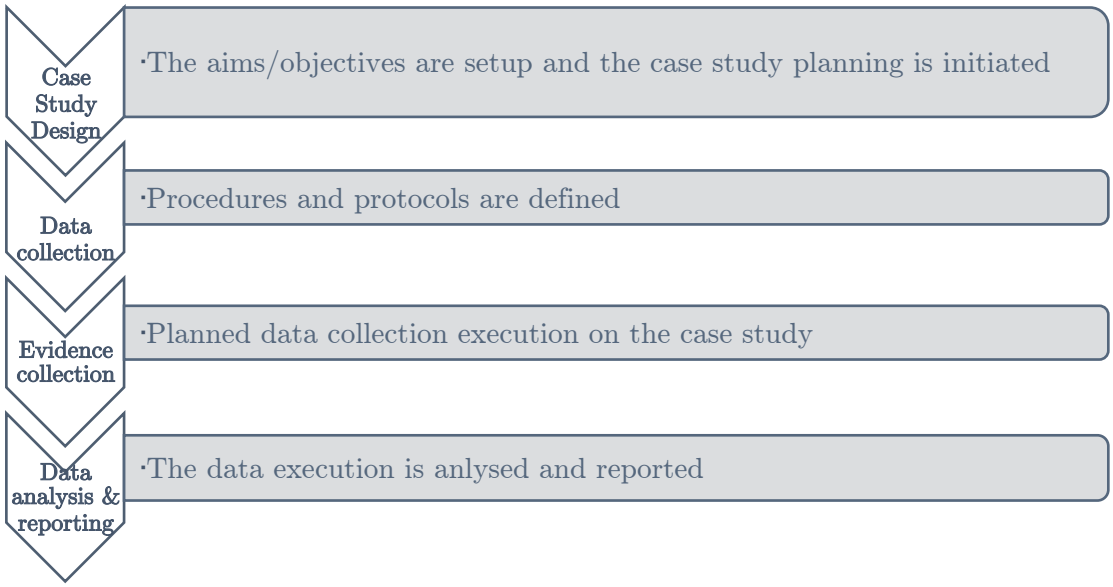


Figure 4-6: Case study design phases (Runeson and Höst, 2009)

Employing a case study validates the technique in principle, hence provides the credibility of the proposed approach. In the current study, case studies are used to evaluate the proposed CMRA instrument's practicality in three real-world cases. In the following sections, the case studies' design and procedures in this research are described.

As illustrated in Figure 4-7, the case studies contain four steps of participant selection, assessment of the university readiness, analysing and reporting the collected data, and finally judging the practicality of the proposed CMRA instrument:

- **Step 1:** Before conducting the case studies, the research sought permission to conduct the case studies in three Saudi universities. Once granted, contact was made with the personnel coordinator in the deanery office to nominate members for the focus groups (Group A participants). As CMRA comprises readiness criteria in different IT domains such as security, IT project planning, Group A participants were selected from various IT backgrounds and expertise such as networking, administration and project management with minimal of two years working experience in the same university or other Saudi unioversities. The main objective of such a diverse selection was to obtain an accurate input assessment of readiness status of cloud migration in their respective universities from personnel working in the field.

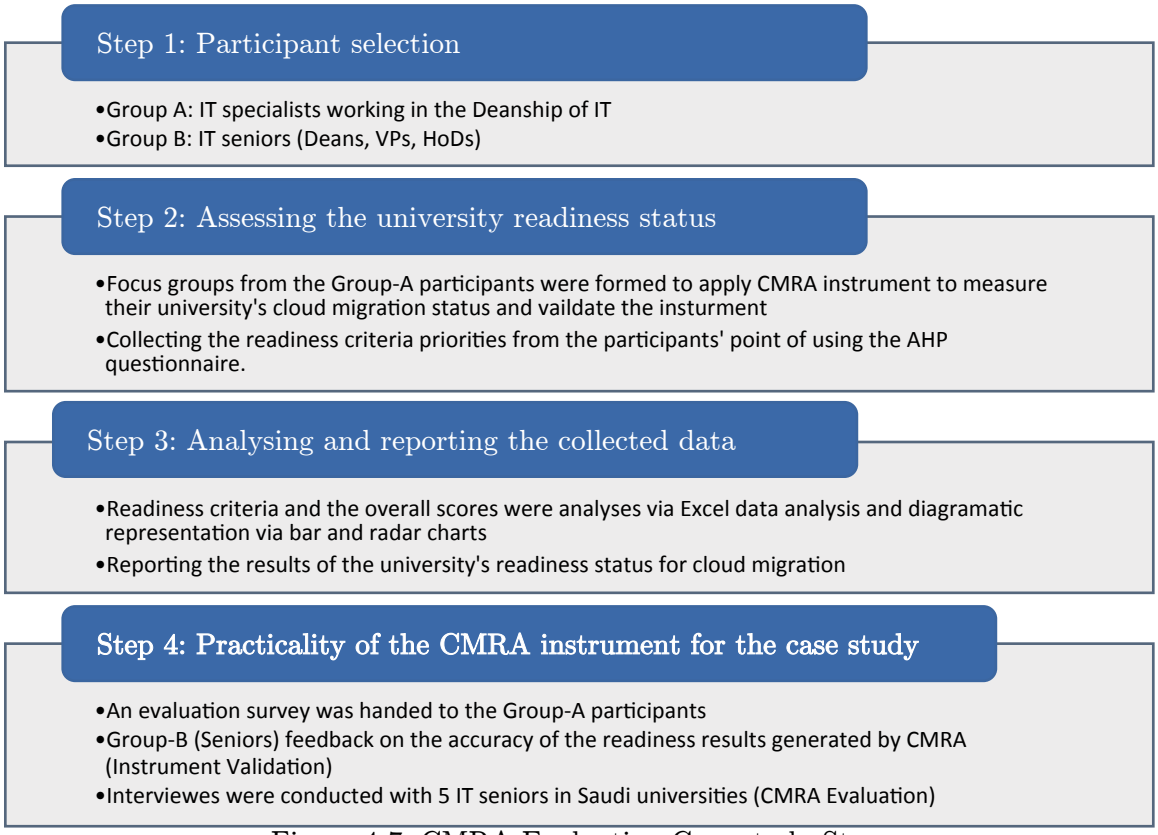


Figure 4-7: CMRA Evaluation Case study Steps

- **Step 2:** In this Step, focus groups were formed with selected IT specialists working in the IT deanships in three Saudi universities. Prior to the interview, the participants were introduced to the participant information sheet and were asked to sign the participation consent form (see Appendix D). Subsequently, the participants were given an online administrated questionnaire containing the questions from the CMRA instrument. The aims of the focus group were to assess their respective university's readiness score for cloud migration by applying the CMRA instrument and also to validate the CMRA instrument's content by suggesting amendments to its assessment measures and criteria.

  The online questionnaire was divided into seven sections. The first contained questions on demographic and cloud migration issues. The remaining six were on the CMRA readiness criteria that were used as measures to calculate the readiness score. Mainly, the questions pertaining to the readiness criteria are rating scales. More details of these can be seen in section 6.1.3. The assessment process focus group interview took approximately two hours at each university. Subsequently, at the end of the assessment process, all the participants were asked to pair-compare the CMRA instrument's readiness criteria priorities to calculate the final readiness score.

- **Step 3**: After collecting the assessment data from the three universities, the results of the assessment sessions were analysed using Excel and were based on a descriptive analytical method. The results were represented as bar and radar charts, which were then included in a results report containing the readiness scores for the technological and organisation domains and the overall readiness score of each university.

- **Step 4**: The practicality of CMRA instrument was first evaluated via 12 Group A participants' questionnaires, as described in detail in section 4.4.3. The questionnaire was distributed to the IT specialists who used the CMRA to assess their university's readiness and to evaluate the CMRA instrument via three constructs, namely, 'perceived usefulness', 'user satisfaction' and 'perception of congruence between expectation of the use and its actual performance'. Moreover, the instrument was evaluated through five seniors' interviews (see interview questions in Appendix K) and five point Likert scale feedback questions on whether the result generated by CMRA in the report on each readiness criteria section reflected their actual readiness status. Five interviews were conducted with IT seniors at the same three universities to seek their perception about their university's readiness for cloud migration before and after seeing the result report generated by CMRA. After being introduced to the report results, they were asked to give their feedback on the accuracy of the results against their university's actual readiness status.

### 4.4.1 Case studies' context and participants

The case studies were conducted in three Saudi universities that had already prepared to migrate their ICT to cloud computing-based services. The aim of the case studies was to measure the readiness of these universities in terms of their preparation for successful migration for cloud services, using the SFCM2 framework and the CMRA instrument proposed in this research. For confidentiality reasons, the actual names of these universities are coded as University-A, University-B and University-C. These case studies were designed to evaluate, by applying the proposed CMRA research instrument, the level of the readiness of these universities to migrate successfully to the cloud. The case studies went through many phases, as explained in Figure 4 7.

A coordinator within the deanery of the IT deanship in each university nominated the participants in the case studies. The participants are categorised into two groups – Group A is of employees or IT experts working in different departments within the IT deanship who participated in evaluating their university readiness level using CMRA instrument in a focus group. The rationale behind choosing participants from various IT departments, such as infrastructure and network, security, application and IT project management, was because each can elaborate more on specific domains of the CMRA instrument, which can result in more robust inputs. For instance, CMRA has security readiness criteria. The IT security specialists in the security department have extensive knowledge of the status of the university's applied security controls, so can contribute better than other departments. After evaluating their university's status, they were introduced to the AHP pair-comparison questionnaire to prioritise the importance of each readiness criterion (RC) in the CMRA instrument. After analysing their inputs in the previous focus group and AHP comparison questionnaire, they were introduced to the results report and were asked to evaluate the CMRA instrument's usefulness and their satisfaction, and give confirmation.

Group-B comprised the seniors working in the IT deanship, such as the dean or the vice-dean or someone on the university board who has involvement with IT projects at the university. They were recruited to the case study to evaluate and reflect on the accuracy of the readiness results generated by applying CMRA to assess their university's status. They were interviewed using semi-structured interviews to seek their pre-perceptions about their readiness to migrate to the cloud. Afterwards, they were presented with the cloud migration readiness results report and asked to reflect on whether the presented results reflect the actual status. Moreover, they were asked to comment on the CMRA instrument and make suggestions to improve it.

### 4.4.2 Case studies' procedures

To assess the readiness for universities' migration to the cloud accurately, a structured online questionnaire was developed to collect IT experts' responses. The CMRA instrument was transformed to an online questionnaire using the University of Southampton iSurvey tool. The questionnaire comprised seven sections and a covering letter section. The letter consisted of a welcome statement and study introduction, definitions of the terms in the study and a consent form. The second section was related to the participants' demographic information and the perceived cloud migration issues in their context. The remaining sections related to the CMRA readiness criteria, to assess the readiness status. The online questionnaire's sections and questions are presented in Appendix E.

During the assessment session, Group A participants were interviewed as a focus group to obtain a clear view of their university's level of readiness by applying the CMRA instrument (using the online questionnaire) to their university for assessment purposes. The online questionnaire was introduced to the participants during the focus group session and their answers were recorded by the researcher. This is called an interview-administrated online questionnaire (Bourque, 2003).

A focus group is regarded as a semi-structured group session managed by a leader in an informal setting with a goal to collect information on an assigned topic. The main advantage of a focus group is that it facilitates interaction to generate data or information. The technique is considered useful as it assists in the development and validation of instruments. Focus group-type interviews were chosen in this study as they provided potentially better opportunities to exchange points of view and stories, as well as allowing participants to challenge each other's narratives, ideas and opinions (Kitzinger, 1995; Morgan, 1996; McLafferty, 2004).

In this study, the sample size of the focus group was between four and six participants for each of the three focus groups. There was one focus group for each of the three Saudi universities, and all their participating members were from different IT departments in the IT deanships in these universities. At the end of the focus group interview session, Group A participants were asked to rank and prioritise the readiness criteria adopted by the CMRA instrument. After collecting the results of each case study, the data was statistically analysed via Microsoft Excel and each readiness criterion assessment result in CMRA was presented to the participants in the form of radar and bar charts in a result report.

Once the case study report was produced, it was presented to both Group A and Group-B participants to seek their feedback on the practicality of the CMRA instrument and how accurate the results were against the actual status. This was done to address the research question RQ2.3: 'How good is the functionality and practicality of the CMRA instrument? This was achieved by the CMRA

evaluation questionnaire for Group-A (Appendix J) and the CMRA evaluation senior interviews for Group-B (Appendix K).

### 4.4.3 CMRA instrument practicality survey

As the aim of the three case studies was to evaluate the practicality of the CMRA to measure the readiness of Saudi universities to migrate to the cloud, a questionnaire survey was designed to examine the feasibility of the proposed instrument. This evaluation was aimed to capture the perception of the IT teams of CMRA and whether they would continue using the instrument to check their readiness.

Hence, this section aims to find the factors that lead to individual acceptance of an instrument. The factors are to be presented on a questionnaire to establish the practicality and applicability of the proposed CMRA framework and to evaluate the post-adoption situation, where individuals are willing to continue using the instrument or not.

The Expectation Confirmation Model (ECM) was adopted to construct the evaluation questionnaire. The model evaluates the aspects of perceived usefulness and satisfaction and its later confirmation after use (Bhattacherjee, 2001). Bhattacherjee (2001) used prior IS usage findings and theories with the theory of Expectation Confirmation to theorise this model of IS continuance.

The ECM proposes variables that reflect the perceived usefulness and satisfaction, as well as a third variable confirming the first two once the instrument has been used (Figure 4-8).

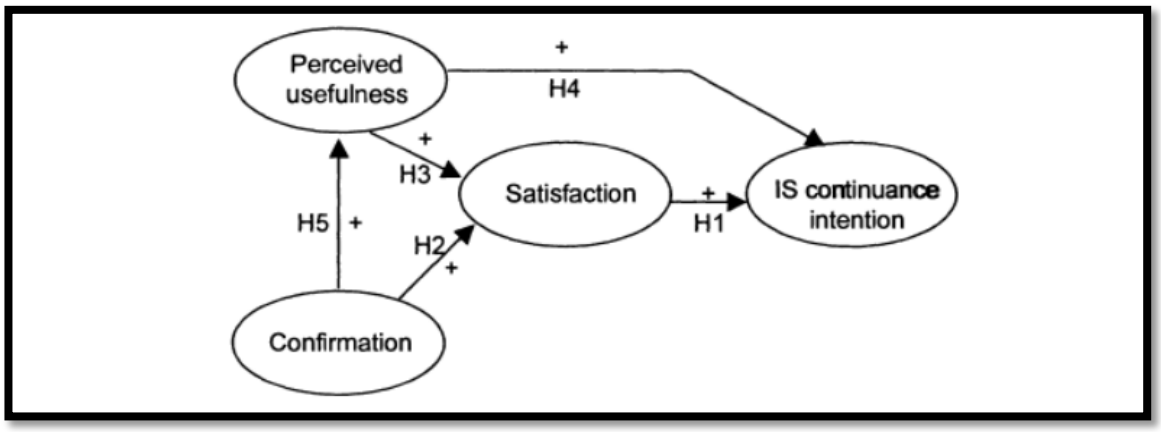


Figure 4-8: ECM of IS continuance (Bhattacherjee, 2001)

The variables in this model are defined as follows:

- **Perceived usefulness**: Determined by user confirmation of expectation from prior use.
- **Satisfaction**: The perceived satisfaction with the instrument before its use

- **Confirmation after use**: A comparison of the perceived effect of the above two variables with the actual confirmation of these two after using the instrument.

### 4.4.4 Ethical approval

The cloud migration readiness assessment case studies were approved by the Ethical Committee of Electronic and Computer Science at the University of Southampton, thus the study met the required ethical standards. The approval to conduct the case studies was granted under reference number **ERGO/FPSE/24380.**

## 4.5 Chapter Summary

In this chapter, the research methodologies that were employed were for confirmation of the proposed SFCM1 framework that was initially developed by conducting a literature review. The methods used for this confirmation were semi-structured interviews with IT experts in IT deanships in Saudi universities and a structured online questionnaire distributed to IT specialists in Saudi universities. Once the proposed framework was confirmed, the framework SFCM2 was converted to an instrument (CMRA) to measure the readiness of Saudi universities for cloud migration. The instrument was evaluated by conducting three case studies to demonstrate its usefulness, practicality and applicability. The findings and the discussions of the framework confirmation are elaborated in the next chapter, and the case studies' results and discussions are presented in Chapter 7.

# Chapter 5

# Confirmatory Study Findings and Results

This chapter presents the outcomes of the statistical analyses carried out on data gathered via a set of mixed methods in order to confirm or reject the role of proposed CSFs in cloud migration in Saudi Arabian universities. The purpose of this chapter is to assess, evaluate and confirm the factors proposed in SFCM1 against the expert interviews and IT questionnaire responses. The techniques used were based on mixed methods via the methodological triangulation technique.

## 5.1 Expert interview findings

This expert interview stage aimed to portray an initial understanding of the proposed framework in order to evaluate certain CSFs objectively. The initial design, based on an in-depth literature review, had to be further evaluated via interviews. It involved IT experts from a similar context, namely Saudi Arabian universities. Initially, based on the literature analysis, ten CSFs were introduced in the study. Based on the interview findings, four more CSFs were suggested by the expert respondents and incorporated. In order to review the proposed framework of this research in the Saudi context, thirteen IT experts working in three Saudi universities were recruited to provide feedback. Of these, only one had experience in existing cloud infrastructure, and that was at King Abdul Aziz University.

### 5.1.1 Analysis of exploratory interview questions

The following bulleted-sections elaborate on the results of various questions asked during the interviews. The questions are grouped as exploratory questions about the current status of cloud migration in Saudi Arabian universities.

- **Current Cloud Deployment in Saudi Universities**

Historically, the universities' deployment focused mainly on IaaS, with a few emphasising Azure-based PaaS architecture trials. There were cases where in-house private cloud implementations were also set up. However, the majority of cloud implementation interest encompassed older universities with a more stable administrative infrastructure. For instance, respondents from Taif University and Jeddah University did not have any experience or consideration of the cloud-based paradigm, which may be attributed to the fact that these are start-up universities

with a low student intake and system load. This can further be understood from the fact that these smaller universities have a staff/student profile of around 20,000, whereas King Abdul Aziz University has around 120,000 students and staff members.

- **Scope of cloud migration**

On querying the type of work for which the cloud platforms are to be used, most respondents focused on better service and hardware provision. There was also a mention of under-utilisation of hardware resources, where in-house servers were only being used to about 15 to 20% of their original capacity. In cloud implementation, a dynamic scaling model was likely to address this computational over- or under-utilisation problem. Moreover, off-site cloud implementation was likely to save physical space and energy. Extensibility of local resources is also a problem where, once an additional need is envisaged, the delivery of additional hardware takes days, if not weeks to arrive, which results in wasting time and driving costs up.

- **Potential challenges and issues in migration**

A question asked by the interviewer that concerned about the challenges and issues in the implementation of a cloud-based infrastructure. The foremost challenge was stated to be the best hardware selection, and the selection of the best storage and server solutions. However, this required careful assessment of the requirements of all stakeholders, due to the fact that the system must be compatible with all existing resources and simple enough for the users (IT specialists) to configure. The system should also be capable of automated control for best performance and selection of the best networking architecture, enabling effective load balancing of the virtual machines. Moreover, two respondents indicated challenges relating to software/application compatibility that may be due to lesser OS versions and installed support libraries. The respondents also pointed out a lack of human resources and the experience required to manage and integrate cloud services within the existing system architecture. For instance, licensing requirements and architectural restrictions may not allow virtualisation on networked machines.

- **Performance of existing cloud infrastructure**

On the level of satisfaction achieved from the services provided by the cloud paradigm, there was substantial support from participants. The factors quoted were the agile and easy-to-use IT services compared to physical servers. It was deemed easier to implement new solutions due to the availability of abundant resources, thanks to the scalability and on-demand aspects integrated in the cloud architecture. This facilitated extensibility, which is a core characteristic of growing enterprises, similar to universities' new campuses and departments. The cloud made it possible to achieve such changes within a matter of days. However, to

adjust to the new system did take a few years to reach a good service and performance level. The respondents were mainly satisfied in general, as it facilitated work and made it possible to switch employee roles and reduce extra employment overheads. The respondents also quoted a solution implementation time saving of three to five months. According to one of the respondents, universities as enterprises should focus on learning, rather than such issues as resource and IT management.

### 5.1.2 Review of technological CSFs findings

The objective of the questions in this section was to gain an understanding of how CSFs were important to a successful migration to the cloud, and the underlying reason(s). In order to achieve this, a set of technological factors was put before the interviewees to assess and evaluate the role of technology in the migration of cloud computing by Saudi universities Table 5-1. The detailed findings for these technological CSFs are elaborated in the following list.

Table 5-1: Experts' Review Analysis of Importance of technological factors

| Code | Yes | No | Uncertain | Theme |
|---|---|---|---|---|
| **Reliability** | 13 | 0 | 0 | 90 – 99% up time |
| **Interoperability** | 10 | 0 | 3 | Cross-vendor migration may potentially result in additional costs |
| **Security & privacy** | 13 | 0 | 0 | There is a decree that forbade data outsourcing to anywhere outside Saudi Arabia |
| **Disaster Recovery** | 11 | 0 | 2 | High costs related to in-house recovery and backup resources |
| **Network Bandwidth** | 10 | 2 | 1 | This is particularly a core requirement if in-house implementation is to be done |

- **Reliability**

From the response summary in Table 5 1, it can be seen that all the respondents pointed to reliability as a crucial factor in cloud migration. However, reaching a high performance of 99.99% is not yet possible for in-house cloud deployment, due to the unavailability of tier-5 data centres. Moreover, redundancy provision in the cloud increased the reliability on the host and site levels, which was deemed highly desirable. For instance, **Respondent 1** commented:

> *'Yes, The infrastructure should be ready and on 99.99%. Reliability is very important factor because before migrating to any new product you should make sure it is very reliable.'*

- **Interoperability**

Roughly 77% (10 of 13) of the respondents supported interoperability as a success factor in cloud migration. Care must be taken at the decision phase to select the stage of platform selection for a cloud environment that is most compatible with your own host application and infrastructure.

There were some uncertain responses that suggested the use of open-source middleware to prevent cross-platform vendor compatibility. **Respondent 4** stated:

> *'It is important to make sure that your existing environment moves smoothly to the new environment, however, in case of a start-up university such as Jeddah University you can start from scratch but you need to make sure that the interoperability between the providers exist to some extent, to avoid vendor lock-in and additional cost and time when you change from one standard to another one.'*

Moreover, there should be a graceful migration mechanism enabling efficient system operation during the migration process, to avoid any existing system failures. This is particularly important if the data volume is huge, as in the case of older universities with a larger user base.

- **Security and Privacy:**

This factor was supported unanimously (13 of 13 respondents) to be crucial in cloud deployment. However, the majority of respondents supported the idea of in-house data hosting for any cloud-based implementation. Five of the 13 respondents specifically mentioned Decree 81 from the Ministers' Council, which forbids the hosting of government data on any international servers. The decree, quoted by one of the respondents, is as follows:

> *'Yes it is very important, because universities have sensitive data, which need more security and privacy techniques. Therefore, to protect the university data, Ministers' Council have issued Decree 81 which has forbidden any governmental institutions to outsource any data on the cloud outside the Saudi borders.'*

Those supporting public clouds stated the importance of using state-of-the-art security standards and encryption techniques to prevent cyber-attacks that may expose user data to third parties.

- **Disaster Recovery:**

The factor was supported by the 11 of 13 participants, with two uncertain responses, mainly due to the fact that public clouds provide disaster recovery by default via geo-redundant and location-redundant backups. Respondent 11 indicated the importance of an in-house cloud as follows:

> *'Yes, I think it is important, but you need to study the budget and the best practices to do it if you are using an in-house cloud or when using a public cloud.'*

However, in-house disaster recovery plans will depend primarily on the budget that one is prepared to set aside to provide backup databases and redundant servers. Moreover, maintaining and running such operations will require expert staff.

- **Network Bandwidth:**

The issue of bandwidth can be taken care of through third-party suppliers such as Amazon and Google, as they operate on a 'pay as you go' basis. However, if the implementation is at the in-house level, bandwidth limitations must be considered. In the study, 10 of 13 respondents indicated the importance of increasing bandwidth to facilitate cloud migration.

### 5.1.3 Review of organisational CSFs findings

Respondents were asked about a number of organisational factors and their role in the success of migration of the cloud paradigm in Saudi Arabia (see Table 5-2). Most participants strongly supported areas of government control, management, SLA requirements and exercising a degree of control. User training was also promoted at staff level.

Table 5-2: Experts' Review Analysis of the Importance of Organisational Factors

| Code | Yes | No | Uncertain | Theme |
|---|---|---|---|---|
| **Ministry of Education Policies** | 13 | 0 | 0 | Only one decree stating that the hosting of government data internationally is strictly prohibited |
| **Management Support** | 13 | 0 | 0 | The funds' authorisation originates from top management called 'administration of purchase' which must overlook this process |
| **User Awareness and Training** | 6 | 3 | 4 | Focus more on IT specialists |
| **SLA Requirements** | 12 | 0 | 1 | Each university should have a customised set of SLA requirements |
| **Degree of Control** | 11 | 0 | 2 | There must be a full control, particularly on sensitive information |

- **Ministry of Education Policies**: All 13 respondents said agreed with the importance of core policies, which were deemed to be not directly from the Ministry of Education but from a sub-council called the 'Experts Council', a sub-council in the Ministers' Council. **Respondent 2** stated:

> *'Yes, but I think the regulation and policies in Saudi Arabia in using IT resource come from the Ministers' Council, not the Ministry of Education. We have received Decree number 81 which prevents us from using public clouds in any governmental organisation issued by the Experts' Council.'*

However, these is no concrete national policy to regulate the use of cloud computing. The only decree in existence is Decree 81, preventing governmental organisations, including universities, from outsourcing their data internationally, for security reasons.

- **Management Support:**

Support of 'administration of purchase' should support and accept all IT projects in terms of cost and benefit, as supported by all 13 respondents. Moreover, any projects to be undertaken must be escalated to the 'deanship of projects' for authorisation by top management. This view was unanimously supported by the respondents as the responsibility for decisions on cost and technical information must be that of individuals at top management level.

- **Staff Training and Awareness:**

Almost half (6) of respondents advised that training should be for IT specialists only, and a substantial number (3) supported the idea of no training at all, due to the simplicity of cloud-based systems.

- **SLA Requirements:**

SLA requirements are of crucial importance in the context of public clouds and should only be used for non-critical information, as stated by three of the respondents. Confidential data such as patents, research and student records must only be hosted in-house, as noted by **Participant 1:**

> *'we will use it only for general data such as university staff general information and not for secrets and sensitive data such as students' records, patents and research materials...'*

In case public option is to be adopted, it must adhere to personalised requirements for each university with penalties for any failures. The set-up must be covered via specialists and legal teams. Other requirements such as service performance, security and privacy levels must form part of the SLA.

- **Degree of Control:**

Eleven of the 13 respondents strongly supported complete control over how the resources were to be hosted on the cloud, particularly sensitive user data. More control must be practised on the migration of financial, administration, intellectual property systems and services, as pointed out by **Participant 6**, as follows:

> *'Yes, it is important to control the data owned by the university and not for public use such as patents, research and financial records, and intellectual property items.'*

### 5.1.4 Additional factors and potential cloud models

The last question in the interview aimed to extract recommendations about additional CSFs, not otherwise mentioned, and their relevance to the previous factors in the initial framework SFCM1. The recommendations by experts are

shown in Figure 5-1. They were then cross-correlated with the SFCM1, and are further discussed and categorised by the participating experts' input below.

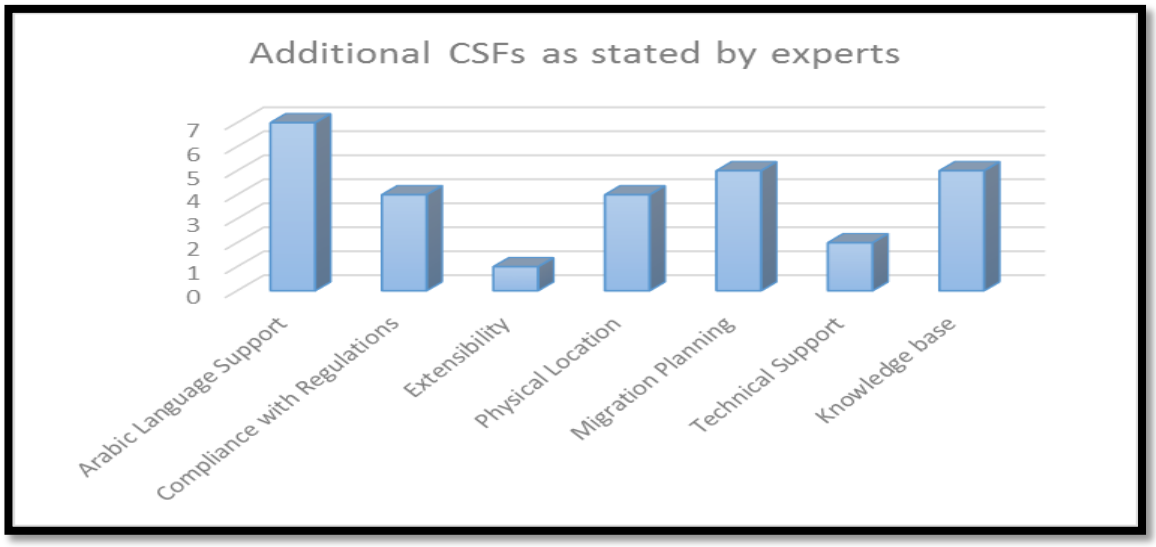


Figure 5-1: Recommended Success Factors by the Respondents

- **Arabic language support**: Arabic language is part of the overall current Saudi government infrastructure and therefore its support forms an integral part of the majority of software systems. One of the seven experts supported Arabic language, as quoted (**Participant 6**):

  *'I think supporting Arabic language is an important factor in different services such as user interfaces for SAS apps, such as Office 365, Web Interfaces.'*

  Arabic language support has long been part of all major operating systems and support tools. As the cloud-based paradigm extends on the same baseline, it is imperative that this support is part of the overall SLA requirements. The language support aspect was further mentioned in conjunction with the overall technical support, as evident in comments made by Participant 11:

  *'Arabic support and technical support and fast response within 24 hours and availability 24/7...'*

- **Compliance with regulations:** Compliance with regulations was another factor suggested by the experts. The country is based on strong supervision by the government sector of all educational and other public service sectors. There is a decree that prevents the outsourcing of cloud and other IT infrastructure bearing critical data to external service providers. This factor was already proposed under Ministry of Education policies, but it was advised that it should be originated at a national level via the regulatory government body. As stated by **Participant 1:**

*'For future use of public cloud, i think physical location of data and which country it is located and what are the data policies regulation and policies is very important and what are the data protection policies applied in each country the data stored in.'*

- **Physical Location:** This was an additional factor that was supported by four of the experts, and correlates to the fact that in the instrument the government regulations are categorised as such. This was further evident in a comment by **Participant 3:**

  *'Physical location and compliance with Saudi Arabia data protection policies'*

- **Migration Plans:** This was suggested by five of the experts. Extending this aspect and the previous responses, the following three sub-categories were understood to be an integral part of the migration planning factor:

  1. **Knowledge-base:** As CSF in this context indicates building a strong repository containing information about service providers' products and prices, security and other best practice and organisational-specific services for the overall migration process. This can be understood by a notable statement by **Participant5:**

     *'Study the provider's performance; prices and the lesson learned from other consumers are very important factors and indicate proper IT project planning.'*

  This factor was included under 'Migration Planning', due to the fact that any strategic decision or plan requires documentation of the lessons learned in the form of a knowledge base.

  2. **IT training:** Following from the knowledge base, IT training can form part of the overall migration plan as it must be performed prior to any migration activities to facilitate having appropriately trained staff available for the new system. This aspect was highlighted in one of the comments by **Participant 7:**

     *'IT specialists need to be trained and this can be one important factor of migrating your system to the cloud, because you have a skilled team that can supervise the new IT environment...'*

  3. **Top Management support:** This factor was unanimously supported by the respondents, which directly links to the overall migration planning: without management support, a plan cannot be executed. This aspect was further emphasised by **Participant 6:**

*'In any IT project, we provide the study that we made and escalate it to the top management and the deanship of projects in the university, and without their support the project will not be authorised...'*

- **Extensibility:** This factor did not originally form a part of the earlier SFCM1. It was only suggested by a single respondent (**Participant 12**):

  *'Extensibility is very important if you are deploying an in-house private cloud.'*

  Interoperability was originally proposed and unanimously agreed with for its importance in successful migration to the cloud. Hence, the Extensibility factor was deemed to form part of the Interoperability CSFs on the basis that, in order for a system to interoperable, it must also have the capability to be extended to meet the future client requirements, as suggested by **Participants 9, 2 and 8.**
- **Technical Support**: This was not mentioned in the earlier SFCM1, but was based on respondents' suggestions and on the idea that service providers must provide technical support in order to meet the SLA commitments. Therefore, it was deemed to form part of the SLA Requirements under the Organisational CSFs.

Despite the Arabic language support and technical support CSFs being indicated separately by a few experts, the two were deemed to be part of the broader SLA requirement aspect of the CSFs, according to the experts' suggestions on respond to the question 'Do you suggest further modifications for the framework categories or success factors?' Similarly, the Knowledge Base and IT Training CSFs can form part of the Migration Planning CSF.

### 5.1.5 Future cloud-model adaptations as suggested by the respondents:

A hybrid setup in which non-critical data is hosted on the public cloud and critical/private data, such as student records, financial information and other administrative database sections, are to be hosted privately in-house will give more control and provide a good balance between scalability, performance monitoring and updates. This approach will also comply with Saudi regulations on organisational data privacy. There can also be a community cloud shared by all the universities to promote knowledge transfer, and this should be accessible to all the organisations that are registered with that community. One of the respondents suggested the idea of extending this community cloud to other national organisations and, ultimately, to an international level to promote mutual research and partnership.

## 5.2 Questionnaire demographic information

The survey was distributed to 55 respondents, but only 41 experienced individuals responded. Figure 5-2 highlights the demographic information from the survey participants. The respondents to the questionnaire worked in IT deanships in Saudi universities, and about 70% belonged to start-up colleges or small-scale institutions.

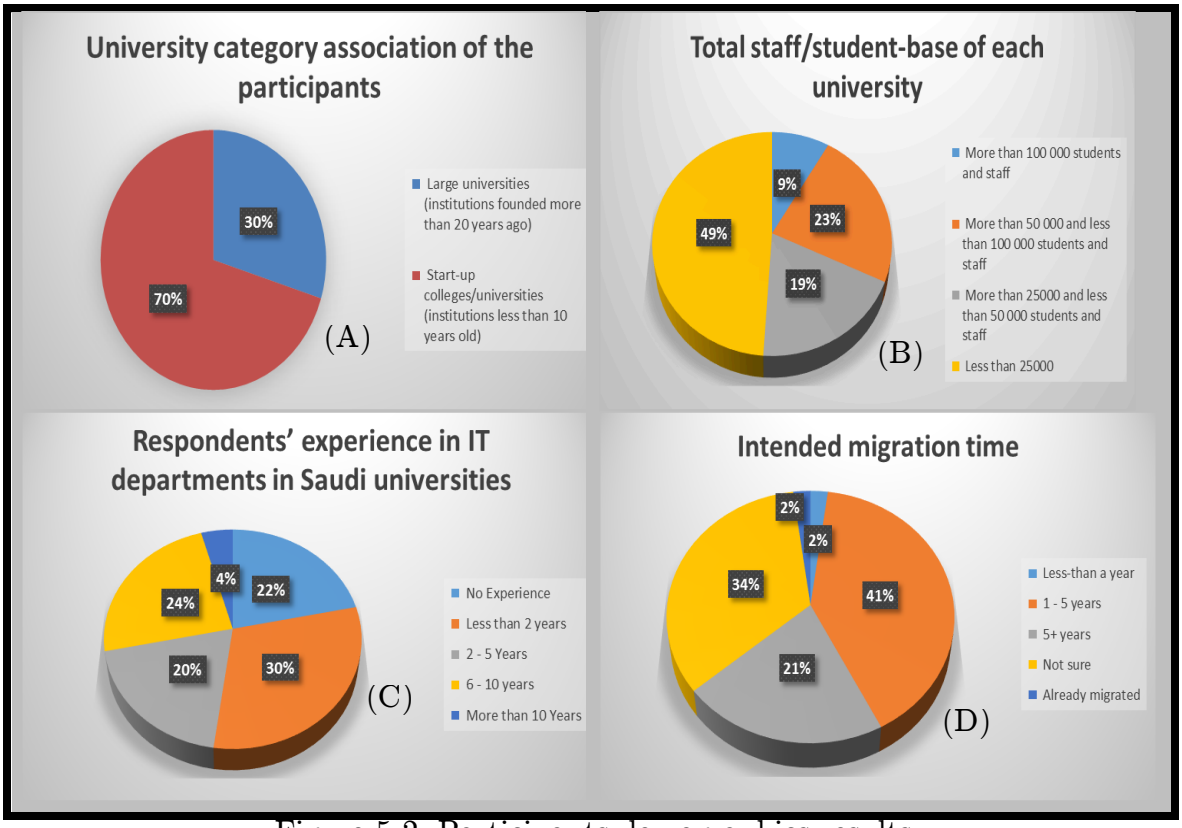


Figure 5-2: Participants demographics results

Due to the nature of most students in universities, the respondents' student and staff-base was predominantly institutions with fewer than 25,000 enrolled students or staff (b). The respondents predominantly had less than two years (30.43%) and between six and 10 years' (23.93%) of experience in the IT industry (c). Moreover, a wide majority (41%) believed their institution to intend to migrate to a cloud-based setup within one to five years, and almost a third (34%) indicated uncertainty about the timescale of the cloud migration (d).

On the question of what type of deployment was preferred, the majority of respondents indicated private cloud deployment that was either in-house or hosted privately by other providers, such as Google (57.57%), see (Table 5-3).

Table 5-3: Preference distributions of various cloud setups

| Cloud deployment type | Number of individuals |
|---|---|
| In-house Private Cloud: within the university or the Saudi Arabian territories. | 20 |
| Private Cloud: hosted by Cloud services Providers ex. Google | 18 |
| Public clouds: Migrating the universities ICT services to Cloud Providers public clouds. | 2 |
| Community Cloud: serving the community of higher education in Saudi Arabia. | 5 |
| Hybrid Cloud: consisting of two of the previous types within the Saudi borders. | 10 |
| Hybrid Cloud: consisting of two of the previous types outside the Saudi borders. | 4 |

## 5.3 Quantitative data analysis

This section provides a detailed analysis of the quantitative data obtained from responses to the technological and organisational questions. The respondents were asked close-ended questions about various factors that could lead to the successful migration of the cloud. The data collected was then analysed by SPSS statistical analysis software via a one-sample t-test measure. The question values for this test were defined on a Likert scale ranging from 5, representing strong agreement, to 1, representing strong disagreement. Before moving ahead with the main t-testing measure, the data was analysed for reliability. A total of 41 experts agreed to respond to the questions in the survey, with input from 95.1% being taken as complete and two data items discarded due to missing information (Table 5-4).

Table 5-4: Summary of the overall data soundness

Case Processing Summary

| | | N | % |
|---|---|---|---|
| Cases | Valid | 39 | 95.1 |
| | Excluded | 2 | 4.9 |
| | Total | 41 | 100.0 |

The data was further evaluated for its internal consistency via Cronbach's alpha to analyse how closely related are a group of items in the overall dataset. The measure was used in order to assess the reliability and consistency of the dataset. The function is written as a function of a number of values and the level of inter-correlation between these items, as shown below (Zeller and Carmines, 1980, p.56):

$$C^{\alpha} = \frac{N.\bar{c}}{\bar{v}+(N-1).\bar{c}} \quad (1)$$

In (1), $N$ is the total number of respondents, $\bar{c}$ is the inter-value correlation and $\bar{v}$ is the average variance over the entire dataset. Based on the equation, it can be understood that increasing the number of items will increase the overall $C^{\alpha}$ whereas an overall inter-value variance will result in a lower alpha value. The

measure was used to evaluate the reliability and inter-value correlation of 24 question-variables with the outcome shown in Table 5-5: The Cronbach's Alpha value of 0.933 indicates a highly reliable dataset.

Table 5-5: Reliability Statistics Cronbach's Alpha

| Reliability Statistics | |
|---|---|
| Cronbach's Alpha | N of Items |
| .933 | 24 |

Having analysed the dataset, the work was then extended to the findings of the quantitative data from the questionnaire respondents. The stage aimed to pinpoint factors with critical role in the migration to cloud-based services within the context of Saudi educational institutions. Table 5-6 contains the results of the one-sample t-test analysis of respondents' inputs to the online questionnaire.

Table 5-6: One-sample T-test analysis of IT deanship experts' inputs

| Success Factors | Items | Sig (2-tailed) | Result |
|---|---|---|---|
| **Technological** | | **Test Value = 3.5** | |
| **Security (SE)** | SE1 | < 0.001 | Statistically significant |
| | SE2 | < 0.001 | Statistically significant |
| | SE3 | .016 | Not statistically significant |
| **Reliability (RE)** | RE1 | < 0.001 | Statistically significant |
| | RE2 | < 0.001 | Statistically significant |
| | RE3 | < 0.001 | Statistically significant |
| | RE4 | < 0.001 | Statistically significant |
| **Interoperability (IN)** | IN1 | < 0.001 | Statistically significant |
| | IN2 | < 0.001 | Statistically significant |
| | IN3 | < 0.001 | Statistically significant |
| | IN4 | < 0.001 | Statistically significant |
| **Organizational** | | | |
| **SLA Requirements (SL)** | SL1 | < 0.001 | Statistically significant |
| | SL2 | < 0.001 | Statistically significant |
| | SL3 | < 0.001 | Statistically significant |
| **Migration Plan (MP)** | MP1 | < 0.001 | Statistically significant |
| | MP2 | < 0.001 | Statistically significant |
| | MP3 | < 0.001 | Statistically significant |
| | MP4 | < 0.001 | Statistically significant |
| | MP5 | < 0.001 | Statistically significant |
| **Compliance with regulations (CR)** | CR1 | < 0.001 | Statistically significant |
| | CR2 | < 0.001 | Statistically significant |
| | CR3 | < 0.001 | Statistically significant |
| | CR4 | < 0.001 | Statistically significant |
| | CR5 | < 0.001 | Statistically significant |

Full details about the CSFs and the items statements are provided in Appendix B. To assess the data, a Bonferri correction was used to ensure that no false positives were introduced into the data. To ensure this, a CSF variable was deemed important only if the p-value of it was $< {}^{\alpha}/_{n} = {}^{0.05}/_{24} = 0.0021$. This value

indicates that the null value hypothesis was rejected only if the respective p-value was $< 0.0021$.

Table 5-7 illustrates t-test statistics, the number of entries N, standard deviation and the mean difference, where all the factors are greater than the defined value, which is 3.5. This value was chosen on the basis that most respondents would either agree or strongly agree with the role of a specific CSF variable or would be neutral. Any other selections would be highly likely to reduce the mean of that variable to a value of less than 3.5.

This aspect was evident from all the variables apart from the 'physical location awareness' variable. Moreover, the statistical significance of this variable and the others was derived via the Sig (2-tailed) comparison against the Bonferri value of 0.0021. The data in Table 5-6 show that all the factors were statistically significant apart from the 'physical location awareness' variable, which was greater than 0.0021.

Aside from this CSF variable, all the values indicated the statistical significance of the remaining 23 variables, as all the values are less than 0.0021. Based on the expert feedback analysis shown in Table 5-7, the importance of all 24 items can be understood from the fact that the means values for all of them were more than 3.5.

From deeper analysis of upper and lower aspects, the top three highly relevant factors are:

1. The security of migrated services (Mean difference: 4.65)
2. Reliability High up-time item (Mean difference: 4.65)
3. Reliability workload handling capability (Mean difference: 4.58)

The least relevant factors are:

- Physical location awareness (Mean difference: 3.88)
- Migration plan and design is critical (Mean difference: 4.2)
- Top management support (Mean difference: 4.24)

Table 5-7: One-sample Statistics

| CSF | Item | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Security (SE) | Migrated service security | 40 | 4.65 | .662 | .105 |
| | Guaranteed privacy | 40 | 4.48 | .816 | .129 |
| | Data Physical location | 40 | 3.88 | .939 | .148 |
| Reliability (RE) | High up-time | 40 | 4.65 | .580 | .092 |
| | Workload handling capability | 40 | 4.58 | .594 | .094 |
| | Provision of recovery plans | 40 | 4.45 | .677 | .107 |
| | Calculated the required network bandwidth | 40 | 4.25 | .809 | .128 |
| Interoperability (IN) | Interoperable with different systems | 40 | 4.35 | .770 | .122 |
| | Interoperable with different service providers | 40 | 4.30 | .791 | .125 |
| | Compatible with existing IT systems | 40 | 4.45 | .677 | .107 |
| | Extensibility | 39 | 4.41 | .785 | .126 |
| Compliance with Regulations (CR) | Government policies adherence | 41 | 4.46 | .869 | .136 |
| | Government standards adherence | 41 | 4.27 | .867 | .135 |
| | Compliance with Saudi regulations | 41 | 4.24 | .799 | .125 |
| | Control overall university data | 41 | 4.37 | .767 | .120 |
| | Control university Sensitive data only | 41 | 4.39 | .945 | .148 |
| Migration planning (MP) | Strategy plan and design is critical | 41 | 4.20 | .715 | .112 |
| | Service provider options | 41 | 4.51 | .711 | .111 |
| | Cloud service options | 41 | 4.29 | 1.006 | .157 |
| | Top management support | 41 | 4.24 | .830 | .130 |
| | IT technical staff training importance | 41 | 4.51 | .711 | .111 |
| SLA-requirements (SL) | SLA adherence importance | 41 | 4.41 | .706 | .110 |
| | Provision of technical support | 41 | 4.56 | .634 | .099 |
| | Supporting Arabic language integration | 40 | 4.30 | .853 | .135 |

## 5.4 Discussions of the findings

This section reports on the findings of the expert interviews and the IT questionnaire survey about the CSFs related to the Saudi context. The expert interviews were carried out with individuals from three different Saudi universities, whereas the IT questionnaire gathered information from IT specialists in the IT deanships of various Saudi universities.

### 5.4.1 Rationale of using expert interviews

The interviews mainly aimed at a critical review of the proposed framework that was based on the literature survey. However, it was understood that most research had a global context. Therefore, in order to gain a context-specific understanding, it was important to set aside various CSFs in the case of Saudi Arabian universities.

### 5.4.2 Justification of employing IT specialists' questionnaires

It must be understood that the initial expert interviews were mainly to establish a base case for the Saudi context. The primary objective of cloud migration was to be addressed by asking individuals working directly within the relevant domain, that is Saudi universities. Therefore, in order to gain a better understanding of the Saudi context, feedback from IT specialists working within this sector was deemed crucial to confirm what was established in a rudimentary way in the earlier two stages (literature survey and expert interviews).

### 5.4.3 Discussions of technological factors:

Based on the interviews, 87.69% of participants strongly supported five technological factors, with just two disagreeing with the importance of network bandwidth requirement importance and only 9.23% (7 respondents) showing uncertainty on some of these factors.

Looking further into the details of these interviews, it was understood that reliability, security and privacy had the unanimous (100%) support of the respondents with regards to the aspects of up-time, cross-vendor migration and government-level compliance. Security, for instance, has been supported by Alshwaier (2012) to uphold the importance of security and privacy by reporting on aspects of identification, authorisation, authentication, integrity, confidentiality, non-repudiation and availability, with a focus on the educational cloud and e-learning. Similarly, the importance of reliability and privacy has been reported in the work of Sultan (2010). The work reported reliability as a serious challenge for the cloud. This may be attributed to the fact that SLA requirements also commit predominantly on reliability processes.

Additionally, interoperability and disaster recovery aspects were supported by 76.7% and 85% of the participants respectively. There was some uncertainty in

terms of the role of network bandwidth requirements, as two of the respondents actually said no to its importance and one was uncertain. In terms of reliability, work by Oya Güner and Sneiders (2014) reports on aspects of reliability and availability having a positive influence on the adoption of cloud computing.

In order to investigate these CSFs further, a questionnaire was used to confirm the CSFs with experts. In the technological context, several questions covering CSFs from earlier interviews as well as the additional factors suggested by the respondents were used as structured questions. Analysis of the IT specialists' feedback showed security and reliability to be the most sought-after CSFs with an average agreement score of 4.62 out of 5. On the latter scale, privacy, disaster recovery, compatibility and extensibility showed an average score of 4.44 out of 5. On a much lower agreement scale, interoperability, and bandwidth received a value of 4.3. Ketel (2014) reports on the challenges on a lack of sufficient internet bandwidth and dynamic storage allocation for disaster recovery as two substantially important aspects. The lowest scoring aspect was found to be of physical location, which had an agreement score of 3.88.

### 5.4.4 Discussions of organisational factors:

Based on the analysis of organisational factors, it was found that 84.61% of the respondents agreed on the importance of most organisational CSFs. Specifically, the CSFs relating to policies and management support were emphasised unanimously. SLA requirements and degree of control were supported by 92.3% and 84.61% of the respondents. Only the CSF of user awareness and training had negative and uncertain responses, with 23.07% saying refuting and 30.76% expressing uncertainty on the importance of this CSF. Moreover, the IT staff training aspect is highlighted as a CSF in Saudi higher education (Aldayel, Aldayel and Al-Mudimigh, 2011).

Similar to the technological case, the organisational context was evaluated using a Likert scale. The factors with the highest agreement were technical support, staff training and knowledge base provision, receiving the highest average agreement score of 4.51 out of 5. Similarly, the degree of control represented by data access control and the service knowledge aspect received a score of 4.38.

Management support, knowledge base, compliance, strategy planning received agreement scores of 4.25 out of 5. The aspect of management support and knowledge base is in compliance with the work reported by Aldayel et al. (2011), reporting project management and top management commitment and support with scores of 10.69 and 6.18 respectively on a scale of up to 11. However, this work focused primarily on ERP implementation in the Saudi context.

Albalawi (2007) reported on the measure of Arabic language support, which matches user feedback on its importance in a proposed cloud migration. The scores obtained both from technological and organisational aspects clearly indicate the

importance of the majority of CSFs, apart from the role of physical location, which indicates that, as far as the security, reliability and other 'high-agreement' aspects are concerned, the location aspect does not bear much importance. The confirmation of the CSFs framework (SFCM2) was carried out on the basis of the IT specialists' and the experts' reviews during the interviews and the surveys that were conducted. The final CSFs confirmed in SFCM2 framework are illustrated in Figure 5-3. Similar to the SFCM1, the SFCM2 has two domains: technological; and organisational. Each has three CSFs and each of these has multiple sub-factors.

In SFCM1, the factors were only groups into two domains: Technological and Organisational, there were only one level of factors. However, the findings and the results outcome of the confirmatory study in this chapter reveal second level of sub-factors as recommended by the experts review. For instance, reliability has two sub-factors (determinants): disaster recovery and network bandwidth. These two sub-factors were introduced in SFCM1 as unrelated factors. However, IT experts have suggested that system's reliability can be measured with both disaster recovery capabilities and adequate network bandwidth available. Therefore, these factors were rearranged to be a sub-critical success factors for the reliability critical success factor. The similar rearrangements were introduced to the other CSFs in SFCM1 as illustrated in Figure 5-3.

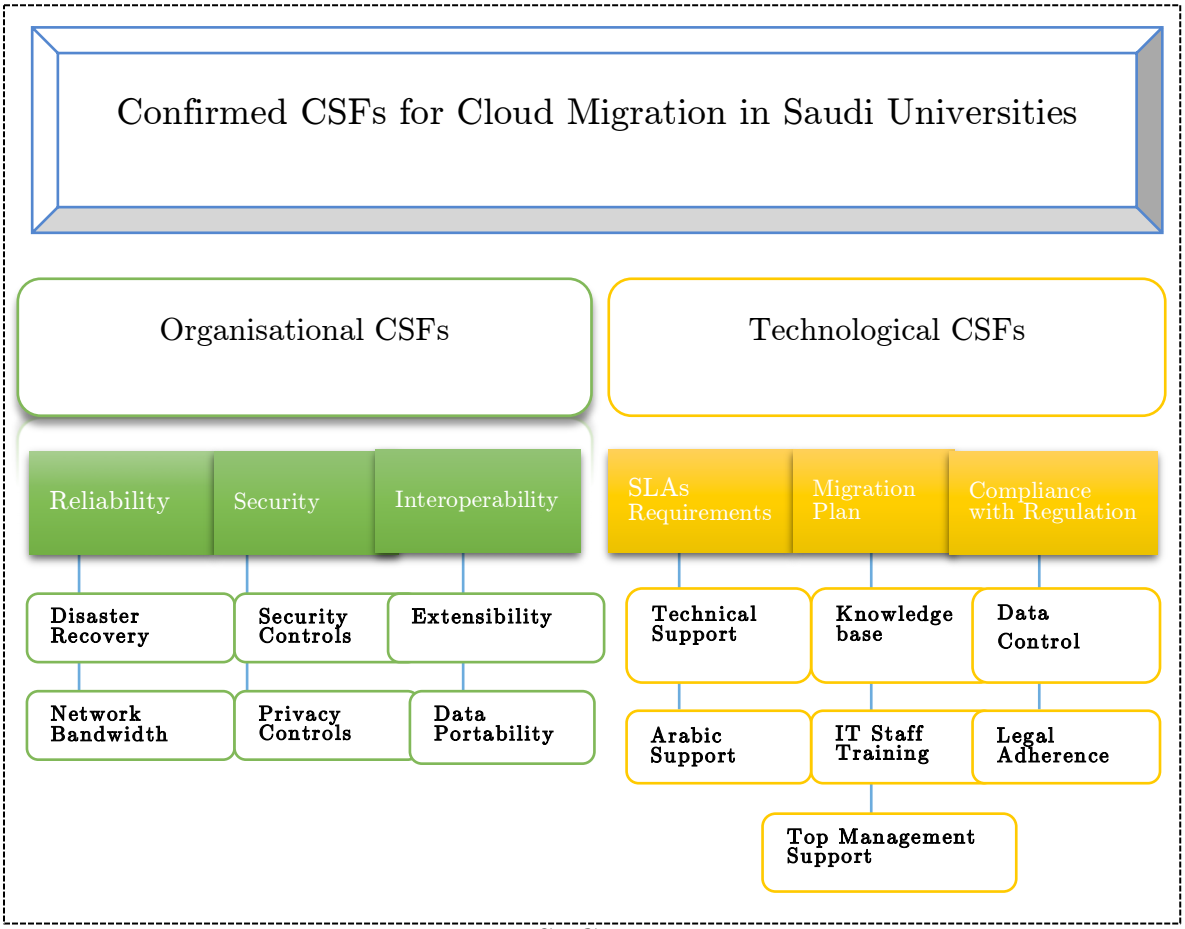


Figure 5-3: SFCM2 Framework

## 5.5 Chapter Summary

Based on their experience, the respondents indicated a number of additional CSFs related to both technological and organisation CSFs, addressing issues of Arabic language support, compliance with the regulations in Saudi Arabia, physical location, migration planning, extensibility, technical support and the knowledge base. The questionnaire results further confirm these factors as CSFs. Most respondents supported an in-house private cloud deployment. Based on the qualitative and quantitative analysis, it was understood that:

- Security and privacy can be achieved in the Saudi context by providing adherence to the original government Decree 81 during the cloud migration process.
- Reliability can be achieved by adhering to quality of service achieving 99.9% up time.
- Interoperability is a crucial aspect as problems during cross-vendor migration may result in additional costs.
- If a decision is made to provide in-house cloud hosting services, aspects such as local backup and recovery may have substantially more costs.
- As advised by the respondents, network bandwidth requirements must be met if the services are hosted in-house.
- The management support factor must originate via top-management personnel.
- User training must focus only on IT specialists.
- The universities must have customisable SLA requirements depending upon the educational services required.
- The process should provide full control of the migration setup, particularly for sensitive data.

# Chapter 6

# Cloud Migration CSFs Instrument Development

Having received and finalised the confirmation of the proposed CSFs framework, it was used as a baseline to develop an instrument to measure the readiness of the universities to migrate to the cloud-computing paradigm. The instrument was based on the GQM approach.

The development of this instrument is the first stage in the validation of the confirmed framework. To achieve this validation and ensure its practicality, a mixed-method instrument was developed. The objective was to allow the universities to measure their readiness to migrate to the cloud. As part of this measuring, CSFs were used as assessment criteria for migration readiness. Each of these CSFs is presented as a set of items, and each of these items is termed as a process in its own, based on user input at the respective university, as each process represents a question. As the tool's goal is measuring readiness, it is called CMRA, the Cloud Migration Readiness Assessment Instrument. The development of this instrument was through a set of stages as shown in Figure 6 1. In Stage 1, the instrument was developed on the basis of the CSFs confirmed by the study presented in Chapter 5. The details of the additional stages in Figure 6 1 are presented in this chapter.

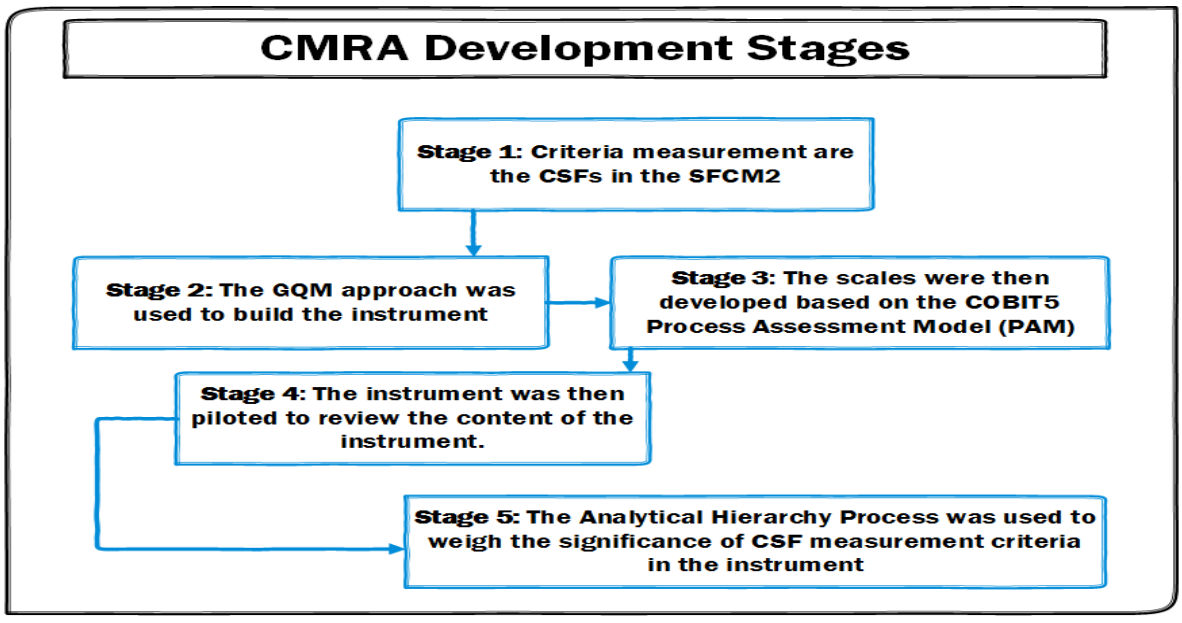


Figure 6-1: CMRA development process

## 6.1 Developing the Instrument using Goal Question Metric (GQM)

In any IT paradigm evaluation process or model, a measurement mechanism is required to obtain feedback to evaluate its effectiveness. The underlying objective is to define a mechanism to test if the process achieved its purpose. The GQM approach assumes that an organisation must specify goals for itself to measure its project efficiently while associating them to the data that is operationally bound to those goals, and ultimately present a framework to interpret that data with regards to the stated goals (Basili, 1992).

A GQM model is a hierarchical structure starting with a goal or object to be measured and the viewpoint from which the measurement is taken. The GQM was developed to address the needs of a goal-oriented approach capable of measuring the processes and products in a software engineering paradigm. The GQM relies on the concept of goal-oriented measurement, with several advantages as described in Basili (1992), Differding, Hoisl and Lott (1996), Stoddard II (1999), and Van Solingen and Berghout (1999), such as:

- It assists in the recognition of beneficial and pertinent metrics
- It also provides convergence on why the metrics are being gathered
- The goals provide a foundation and setting for the assessment and understanding of the collected data

The GQM enables the identification of metrics and the underlying convergence capability about why such metrics are gathered in the first place, and provides the capability to assess and understand the collected data. Hence, the research instrument is evaluated by conducting case studies, and employs the concept of the GQM approach to develop the research instrument (CMRA). The idea of GQM being used as a template, as shown in Figure 6-2, is to develop a goal, whereas the actual procedure is the goal-related questions and metrics.

This will assist in developing the CMRA goal (assessing organisation readiness for cloud migration), questions (success factors' processes) and metrics (quantitative subject ratings and qualitative description). The GQM has three levels that are defined as follows:

### A. Conceptual level (Goal)

A goal is defined for an object for many reasons, including quality or points of view with regards to a specific environment, which is the objective of this study. The object types could be products such as artefacts and deliverables, processes such as time-associated activities, and resources such as personnel, hardware and/or software. This research focuses mainly on the processes or resources part of the GQM goal (Basili, 1992; Differding, Hoisl and Lott, 1996).

#### B. Operational level (Question)

At this level, a set of questions is used to characterise how a specific goal is going to be assessed/achieved, based on some characterising model. Hence, the questions attempt to identify an object of measurement (e.g. process or resource) with regards to a selected quality issue (e.g. calculation of network bandwidth) (Basili, 1992; Stoddard II, 1999).

#### C. Quantitative level (Metric)

At the quantitative level, a set of data is associated with each question to answer it in a quantifiable way. The data can either be subjective or objective. Objective data is where the object being measured is such as staff hours or processing time. In the case of subjective data, it may represent a viewpoint, hence cannot be calculated precisely, such as with text readability, satisfaction and readiness (Basili, 1992; Differding, Hoisl and Lott, 1996; Van Solingen and Berghout, 1999).

### 6.1.1 Applying the GQM approach to the CMRA instrument

Based on the confirmed CSF framework, the migration readiness requirements were divided into two domains: technological readiness requirements, containing the criteria of reliability, security, and interoperability; and organisational readiness requirements, containing SLA requirements, a migration plan and compliance with regulations criteria. The readiness criteria identified were based on the exploratory study (Alharthi et al., 2017).

In GQM, a goal is defined for various objects for a variety of reasons and from variable viewpoints. The GQM defines a template to describe these attributes for a measurement case which, in our situation, is assessing organisations' readiness for cloud migration, as defined below:

- **Purpose**: Assessing the overall Readiness of organisation to migrate to the cloud
- **Object**: Organisation resources (Infrastructure + Human Factors + Practices)
- **Issue**: Cloud migration readiness status
- **Perspective**: Self-readiness requirements
- **Viewpoint**: IT Project Managers, specialists and experts
- **Environment**: Educational organisation, IT Stakeholders
- **When**: Prior to the initiation of the migration process

Figure 6-2 shows the proposed GQM model to measure the readiness goals of any organisation that willing to migrate to the cloud. In this figure, a goal is abbreviated to G and each sub-goal (a CSF) is represented as SG, which in turn represents a readiness criterion (RC), preceded by a number indicating one of the six CSFs, hence SG1 to SG6. Each SG is broken into a set of processes (measures),

represented as questions (PQs) in the proposed GQM approach. There are two subjective metrics (SMs) in this model, SM1: subjective rating scores derived from the COBIT5 model scale; and SM2: a qualitative input explaining the scoring rate.

Each SG comprises several measuring processes labelled as SG1.PQ1 to SG1.PQn for each question (process), the number of the processes varies for each SG. Each SG1.PQ1.M represents the metric associated with SG1.PQ1, and so on. The sub goals represented in the figures are: SG1: Reliability, SG2: Security, SG3: Interoperability, SG4: SLA Requirements, SG5: Migration plan, SG6: Compliance to the regulation.

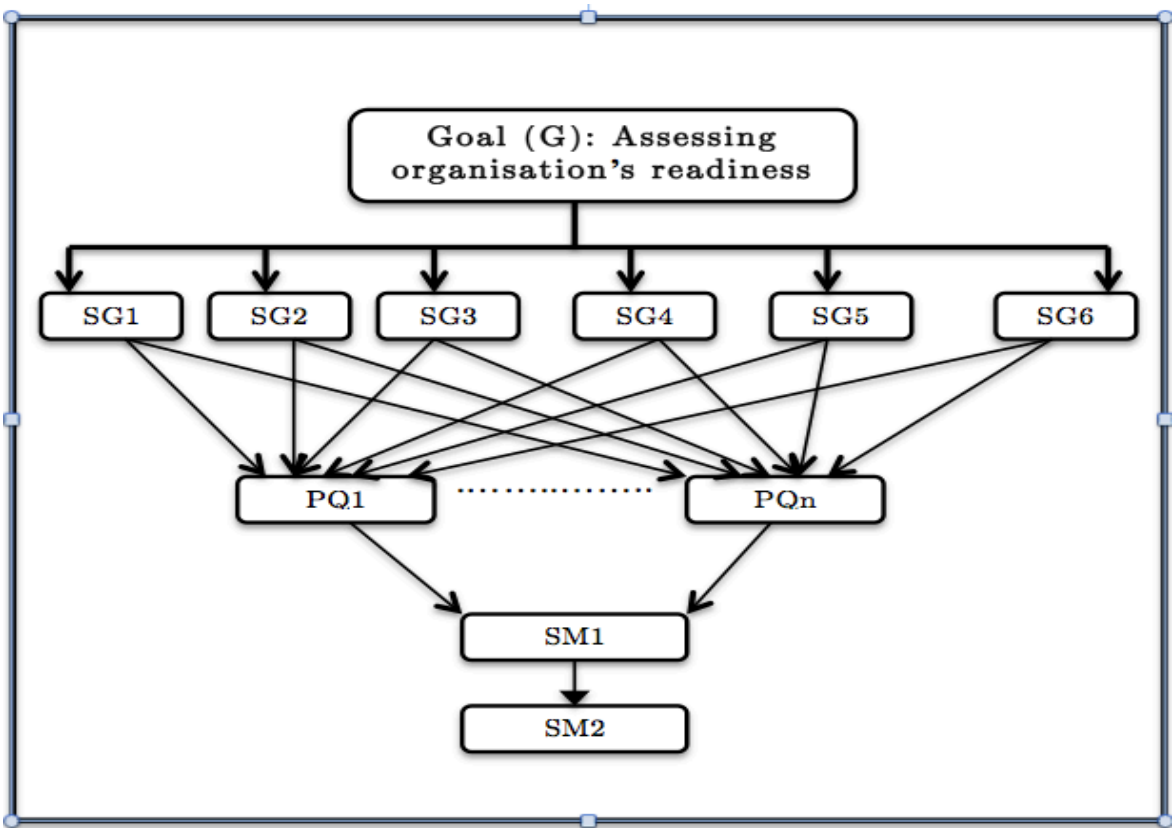


Figure 6-2: GQM Model for assessing cloud migration readiness

### 6.1.2 Building the GQM model for CMRA

The main goal, as shown in Figure 6-2, was to assess the readiness of the university for cloud migration. The main goal was divided into sub-goals (RC), which then are further organised into a set of processes. For each RC, a viewpoint template needs to be defined for the migration readiness assessment. These RCs templates are discussed in details below:

- **Technological Domain Readiness Criteria:**

**A– Reliability:** The sub-goal system reliability in this study for an organisation is defined as preparation and awareness to ensure that the migrated systems or services to the cloud operate their required functions without failure during specified workload times and conditions based on the literature and previous

research (Garg, Versteeg and Buyya, 2011; Loebbecke, Thomas and Ullrich, 2011; Alharthi *et al.*, 2017).

Refining the reliability goal into PQs measures for assessing reliability status, these PQs include issues related to network bandwidth, data latency, disaster recovery and availability as shown in Table 6-1.

Table 6-1: Measuring processes for the reliability sub-goal

| SG1: Reliability | | Measuring Processes (PQ1 – PQ7) | Metrics |
|---|---|---|---|
| **Purpose** | Assessing reliability | Q: What do you think the status of the following processes in your respective organisation? | • ***Rating Score (Process Assessment Model (PAM) modified scale):*** 1 - No existent process, 2 – Initial process, 3 - Defined Process, 4 - Managed Process, 5 - Optimised Process.<br>• ***Qualitative Inputs.*** |
| **Issues:**<br>**Bandwidth (BW)**<br>**Disaster recovery (DR)**<br>**Availability (AV)**<br>**Data Latency (DL)** | | The implementation of recovery techniques e.g. (via redundancy datacentre, network, backups) for the services affected by disasters or failures **(DR)** | |
| **Viewpoint** | University and IT project managers | The calculation of the organisation required network bandwidth for hosting/running all the organisation services on the cloud **(BW)** | |
| | | The assessment of the data latency rate of the migrated services (which services accept High latency/ and which require low latency) **(DL)** | |
| | | The identification of the required high up time for all the University IT services (availability requirements) e.g. 24/7 or certain working hours or days **(AV)** | |
| | | The capability of identifying the system's workload spike times, (e.g. during certain hours of the day, month or academic semester) **(AV)** | |

## B- Security:

The security sub-goal in this study is defined as a set of security controls and activities (practices + awareness) that describe attributes such as confidentiality, integrity, availability, authenticity and non-repudiation of the goal.

In Table 6-2, the processes related to this sub-goal are aiming to measure security infrastructure and practices for the university to keep its migrated hardware, software and data to the cloud protected against threats or attacks from unauthorised entity, malicious software, and attacks on the overall organisation (Islam and Falcarin, 2011; Conway and Curry, 2015; Stanton, Theofanos and Joshi, 2015).

Table 6-2: Measuring processes for the security sub-goal

| SG2: Security | | Measuring Processes (PQ1 – PQ13) | Metrics |
|---|---|---|---|
| **Purpose** | Assessing security | Q: What do you think the status of the following processes in your respective organisation? | • ***Rating Score (Process Assessment Model (PAM) modified scale):*** 1 - No existent process, 2 – Initial process, 3 - Defined Process, 4 - Managed Process, 5 - Optimised Process.<br>• ***Qualitative Inputs*** |
| **Issues:**<br>Privacy **(PV)**<br>Confidentiality **(CF)**<br>Integrity **(INT)**<br>Non-repudiation **(NR)**<br>Security Awareness **(SA)**<br>Physical Security **(PS)**<br>Security Auditing **(SD)**<br>Malicious Detection **(MD)** | | The awareness of security risks associated with migrating the resources to the cloud e.g. (Vendor lock-in, data leakage, multi-tenancy attacks) **(SA)** | |
| **Viewpoint** | University and IT project managers | The categorisation of the critical mission services (security-sensitive) and non-sensitive services **(SA)** | |
| | | The alignment between the selection of the different cloud deployment models (Public, Private, Community and Hybrid) and service models (IaaS, PaaS and SaaS), and your University security requirements. **(SA)** | |
| | | The evaluation of data centre protection e.g. (building safety) either in the organisation or in the provider location **(PS)** | |
| | | The implementation / awareness of the privacy controls required to the information on the cloud e.g. (Encryption algorithms, password length) **(PV)** | |
| | | The documentation of overall security requirements (Policies) for the migrated services. **(SA)** | |
| | | The assessment of the all security mechanisms if they work, update properly and do the required security goals and policies **(SD)** | |
| | | The capabilities of validating all the system stakeholders' credentials **(CF)** | |
| | | The assurance of Information protection against the unauthorized accesses e.g. (employing security protocol SSL/TLS, access control list) **(CF)** | |
| | | The capability to keep the information protected from the unauthorised modifications by employing cryptographic methods such as comparing the received data hash with the hash of the original message) **(INT)** | |
| | | The controls applied to prevent users and parties to deny after participation in any interaction such as communications, transactions among parties e.g (Proof of transaction attributes such as Date, time and identity of interacting parties) **(NR)** | |
| | | The controls applied to detect the malicious activities e.g. (Firewalls, Honeypots and intrusion detections) **(MD)** | |
| | | The adoption of information security standards e.g. 'ISO/IEC27001' and 'COBIT5' **(SA)** | |

## C– Interoperability:

The sub-goal of interoperability is defined in this study as a set of preparations and evaluation activities performed by the University to assess the ability of its systems and services to exchange information and mutually use the information with different cloud service providers in order to cooperate and interoperate with each other (Table 6-3) (Garg, Versteeg and Buyya, 2011; Standards Customer Council, 2014; Conway and Curry, 2015).

Table 6-3: Measuring processes for the Interoperability sub-goal

| SG3: Interoperability | | Measuring Processes (PQ1 – PQ7) | Metrics |
|---|---|---|---|
| **Purpose** | Assessing interoperability | Q: What do you think the status of the following processes in your respective organisation? | • ***R Rating Score (Process Assessment Model (PAM) modified scale):*** 1 - No existent process, 2 – Initial process, 3 - Defined Process, 4 - Managed Process, 5 - Optimised Process.<br>• ***Qualitative Inputs*** |
| **Issues**: Portability **(PT)** Interoperability Awareness & Practices **(IP)** Extensibility **(EX)** | | The evaluation of the organisation data portability e.g. (the format of the organisation data is compatible with the potential cloud provider data type). **(PT)** | |
| **Viewpoint** | University and IT project managers | The identification of the required level of interoperability for the migrated applications based on the service models (Low level SaaS, Medium level PaaS and high level IaaS). **(IP)** | |
| | | The awareness of standards to ensure interoperability of applications on the cloud e.g. (Open virtualisation Format (OVF), Cloud Data Management interface (CDMI)). **(IP)** | |
| | | The consideration of implementing Enterprise Service Bus (ESB) to perform interface, protocol and data transformations to address differences between different cloud providers. **(IP)** | |
| | | The evaluation of whether the migrated applications are leveraging SOA design principles. **(IP)** | |
| | | The identification of the organisation's applications architecture that support scaling out to multiple servers. **(EX)** | |
| | | The recognition of the organisation legacy systems that require special access to hardware components **(IP)** | |

- **Organisational Domain Readiness criteria:**

### D- SLA-Requirements:

The sub-goal of SLA requirement is defined in this study as a prepared list of customised service-level agreement requirements for each migrated service by the university. The requirements in Table 6-4 should be indicated in the SLA to cover the end-user experience and the customer's operations (Alhamad, Dillon and Chang, 2010; Garg, Versteeg and Buyya, 2011; Conway and Curry, 2015; Alharthi et al., 2017).

Table 6-4: Measuring processes for the SLA-Requirements sub-goal

| SG4: SLA-Requirements | | Measuring Processes (PQ1 – PQ8) | Metrics |
|---|---|---|---|
| **Purpose** | Assessing SLA Requirements | Q: What do you think the status of the following processes in your respective organisation? | • ***Rating Score (Process Assessment Model (PAM) modified scale):*** 1 - No existent process, 2 – Initial process, 3 - Defined Process, 4 - Managed Process, 5 - Optimised Process.<br>• ***Qualitative Inputs*** |
| **Issues**:<br>Technical support level **(TS)**<br>Arabic language support **(AL)**<br>Service level requirements **(SL)**<br>Cost requirements **(CR)**<br>Penalties **(PN)**<br>Security Requirements **(SR)** | | The identification of the required levels of services for the migrated services to the cloud e.g. (the expected availability time or locations). **(SL)** | |
| **Viewpoint** | University and IT project managers | The customisation of security requirements for each service migrated to the cloud e.g. (the ability to manage security terms in the cloud SLA) **(SR)** | |
| | | The technical support requirements are prepared and can be negotiated with the service provider e.g. (Help desk in the organisation or multilingual support). **(TS)** | |
| | | The identification of the services that required customisation e.g.(the adaptation of Arabic language in user interfaces or support accessibility needs). **(AL)** | |
| | | The documentation of the required compensation and remediation when fault and failure occur e.g.(the penalties required if the guaranteed service level is not met). **(PN)** | |
| | | Defining the satisfied cost requirements for the services migrated e.g. (accepted cost for: one unit of CPU unit, storage, RAM and network for each VM used). **(CR)** | |
| | | The establishment of the cloud request for proposal (RFP) document (tender documentation). **(SL)** | |
| | | Defining the accepted get-out or exit procedures and clauses in the SLA contract e.g. (the time to move to another cloud provider or how to make sure the data is removed from the previous provider storage). **(SL)** | |

## E- Migration Plan:

The sub-goal migration plan is defined in this study as the preparedness and planning by the university that is performed before migrating its ICT services to the cloud. As depicted in Table 6-5, this migration planning involved activities such as building the knowledge base, training IT staff and gaining the support of the top management board (Carcary, Doherty and Conway, 2006; Garrison, Kim and Wakefield, 2012; Abdollahzadehgan et al., 2013; Conway and Curry, 2015; Standards Customer Council, 2016; Alkhalil, Sahandi and John, 2017).

Table 6-5: Measuring processes for the Migration Plan sub-goal

| SG5: Migration Plan | | Measuring Processes (PQ1 – PQ6) | Metrics |
|---|---|---|---|
| **Purpose** | Assessing Migration Plan | Q: What do you think the status of the following processes in your respective organisation? | • ***Rating Score (Process Assessment Model (PAM) modified scale):*** 1 - No existent process, 2 – Initial process, 3 - Defined Process, 4 - Managed Process, 5 - Optimised Process.<br>• ***Qualitative Inputs.*** |
| **Issues**<br>Knowledge-base **(KB)**<br>IT staff training **(ST)**<br>Management support **(MS)**<br>Performance assessment **(PA)** | | Establishing the strategic plans and objectives of cloud computing within the IT strategy **(MS)** | |
| **Viewpoint** | University and IT project managers | Involving the stakeholders (management board, IT staff, employee) in assessing service readiness for the cloud (**MS**) | |
| | | Gathering intelligence on cloud services and providers offerings e.g. (structured resources such as successful migrated projects, Experts views, using evaluating tools e.g. SMICLOUD) **(KB)** | |
| | | The identification of the required IT skills to migrate to the cloud against the available skills (Developing required cloud skills Training Programs) **(ST)** | |
| | | Defining the suitable metrics to measure the impact of the migrated services e.g. (assessing cost savings or validate SLA compliance) **(PA)** | |
| | | The support of board of directors to cloud migration project and investment in your University e.g. (Managing IS human resources, budget and objectives of cloud usage) **(MS)** | |

## F- Compliance with regulations:

The sub-goal of compliance with regulations is defined in this study as a set of practices that the university is aware of/applies to comply with the country's regulations that govern cloud services usage or hosts (Iankoulova, 2011; Khajeh Hosseini et al., 2011; Subashini and Kavitha, 2011; Lian, Yen and Wang, 2014). To measure the status of this sub-goal, issues such as the degree of data control that the university can tolerate, adherence to government regulations and the existence of cloud usage policies were investigated, as described in Table 6-6.

Table 6-6: Measuring processes for the Compliance with Regulations sub-goal

| SG6: Compliance with Regulations | | Measuring Processes (PQ1 – PQ5) | Metrics |
|---|---|---|---|
| **Purpose** | Assessing Compliance with Regulations | Q: What do you think the status of the following processes in your respective organisation? | |
| **Issues:**<br>Degree of data control **(DC)**<br>Adherence to local regulations **(LR)**<br>Data usage policies **(DP)** | | The identification of the local regulatory requirements to host or outsource to cloud services e.g. (awareness of cloud usage local regulations) (LR) | ***Rating Score (Process Assessment Model (PAM) modified scale):***<br>1 - No existent process, 2 – Initial process, 3 - Defined Process, 4 - Managed Process, 5 - Optimised Process.<br>***Qualitative Inputs*** |
| **Viewpoint** | University and IT project managers | Declaration policies to regulate the usage of the data on the cloud (Data ownership policies) (DP) | |
| | | Identifying the cloud services and providers that adhere to the country regulations e.g. (licensed vendors) (LR) | |
| | | The alignment between the organisation cloud requirements and the government legal and regulatory requirements including those related to security, privacy and accessibility (LR) | |
| | | Defining the requirements to control the data over the functionality of the cloud services e.g. (how sensitive data will be controlled) (DC) | |

### 6.1.3 CMRA instrument metrics

The CMRA instrument adopts a subjective rating score. Since each process in this case depends on many criteria, it differs from one university to another, hence the subjective rating score is used to measure the maturity of cloud migration readiness status. One example of such a case is measuring network bandwidth, which cannot be represented as a definite value, such as 2GB, as it depends upon many factors such as workload, number of users and type of applications currently loaded onto the system. Therefore, the scale was adopted from the PAM model (Isaca, 2011). The rationale behind using this scale is that COBIT5 provides a basis for assessing an organisation's IT processes' maturity. COBIT is a universal framework that can provide a strong IT work audit programme. As the aim of this research is to assess the readiness for cloud migration, which is in line with the PAM model, its usage is justified in the proposed readiness assessment scope. The original PAM metrics are as follows:

- 0: Non-existent
- 1: Initial
- 2: Repeatable
- 3: Defined
- 4: Managed
- 5: Optimised

Based on previous literature reviewed and during the content validation panels with experts for CMRA, the 'Repeatable' level in the scale has been removed from the proposed metrics below. The justification is in section 6.2. A textual description of the modified and derived metric levels from PAM is presented as follows:

- **Level 0 Non-existent process (0%)**: the process is not implemented, thought-of or with any awareness, which indicates that *'There are major issues and weakness areas (Inappropriate Areas) and serious consideration is required before migrating to the cloud'*
- **Level 1 Initial/Incomplete (25%):** the process is not implemented adequately, but is being considered and there is some awareness, which indicates that *'The processes at this level are (Below Average) and require substantial improvement before migrating your system to the cloud'*
- **Level 2 Defined/Performed process (50%)**: the process has an immature implementation but has defined formal capabilities, which indicates that *'The area remains at an average scale (Adequate Areas) and needs considerable improvement to enable an appropriate cloud migration'.*
- **Level 3 Managed process (75%)**: the process is now implemented in managed fashion (planned, monitored, measured and adjusted) which indicates that *'The processes at this level are well-established (Good Areas); however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration'.*
- **Level 4: Optimised process (100%)**: the process is continuously improved and best practices are followed to monitor and manage the business goals, which indicates that *'Be persistent and no improvement required, that is, the process area is managed quite well (Excellent Areas) and no action needs to be taken before considering the migration process'.*

## 6.2 Validating the CMRA instrument content

Validating the research instrument before undertaking the real-world research is crucial. Hence, to ensure content and validity (Runeson and Höst, 2009; Bhattachejee, 2012; Arpaci, Kilicer and Bardakci, 2015), first the instrument was designed based on the literature, as stated in section 6.1.2. Secondly six individual experts, four of them experienced in cloud-computing research and industry and the remaining two from a computer science research background, working at the

University of Southampton, took part in the expert panel to evaluate the content validity of the measures in CMRA. Based on the expert feedback, certain modifications were made to the instrument.

During the Instrument Content Validity revision phase, the participants were introduced to the proposed metrics in section 6.1.3. They agreed on all the scale levels apart from 'Repeatable', which they described as an unclear level of the scale and hence deemed it unnecessary. Therefore, all factors relevant to CMRA were based on this metric without the 'Repeatable' measure, as suggested from a similar study conducted in the Saudi context (Alreemy et al., 2016). Then, to improve the readability of the responses, each answer was given a comparable percentage to indicate the success level of that factor. It is understandable that 'non-existent' is equal to zero and that 'optimised' is 100%, thereby making the parameters between 25%, 50%, 75% when 100% is divided by four.

The instrument's total measuring processes (PQs) numbered 49, and four were ultimately removed on the basis of their repetition, duplication or unsuitability to measure their relevant RCs. The main question was: 'To what extent do you agree that the following measuring items are relevant to measure the readiness of the organisation's X readiness criterion?', where X refers to each of the RCs in the CMRA instrument. Experts were asked to indicate their level of agreement using a five-point Likert scale ranging from 'Strongly Agree' to 'Strongly Disagree'. A full list of the content validity questions for the expert interview panel can be seen in Appendix C.

## 6.3 Priority ranking of readiness criteria in CMRA

Since the research instrument has six readiness criteria, it is a type of multi-criteria decision-making (MCDM) instrument, where the importance of each criteria may differ from university to university according to their individual circumstances, such as workloads, applications and resources. For instance, one university's priority might be the security aspect of readiness, whereas for another it might be a reliable and trustworthy system. Therefore, a technique is required to decide the priorities of the university's decision-makers for the readiness criteria. The Analytical Hierarchy Process (AHP) is one such technique, which is used in this research to address the ranking of the priorities of the CMRA readiness criteria. The different universities' rankings of the instrument readiness criteria were collected via a pairwise comparison questionnaire (see Appendix F).

### 6.3.1 Analytic Hierarchy Process (AHP)

MCDM is a process for evaluating alternatives for selection or ranking (Özcan, Çelebi and Esnaf, 2011). There is a wide range of methods and approaches to

support decision-making in various fields, including management and planning, outsourcing and investment. These techniques include the AHP and the Technique for Order of Preference Similarity to Ideal Solution (TOPSIS). The AHP is defined as a measurement theory conducted via pairwise comparisons, where it relies on the judgement of experts to derive priority scales (Saaty, 2008). The technique is widely used in the domain of outsourcing as it is related to cloud migration (Min and Perçin, 2009). In Information system research(IS), AHP was used in outsourcing by Akomode, Lees and Irgens (1998), Yang and Huang (2000) and Bruno et al. (2012). The concept has been extended for use in selecting service providers in a cloud-computing environment (Menzel and Ranjan, 2012).

The research advancements in MCDM identify several differences and similarities in AHP and TOPSIS. According to Özcan et al. (2011), these two areas differ in five key aspects, as summarised in Table 6-7:

Table 6-7: Comparison of AHP and TOPSIS (Özcan, Çelebi and Esnaf, 2011)

| Key criteria | AHP | TOPSIS |
|---|---|---|
| Core process | Hierarchical structure creation and pairwise comparison matrices | Distance calculated to positive and negative ideal point |
| Determination of weights | Pairwise comparison matrices on 1 – 9 scale | No method specified and linear or vector normalisation |
| Number and type of outranking relations | N (N-1)/2 | 1 |
| Consistency check | Exists | None |
| Problem structure | Quantitative or qualitative data with small number of alternatives and criteria | Objective and quantitative data with large number of alternatives and criteria |

The comparative analysis shown in Table 6-7 shows AHP to be more suitable than the TOPSIS as an approach supporting cloud computing selection and ranking of the readiness criteria.

According to Saaty (2008), to make a well-organised decision to generate priorities, the decision should be decomposed into certain steps as follows:

- Problem definition and the determination of the type of knowledge sought
- Structure the decision hierarchy as:
  - **Top:** The decision goal is the objectives from a broader perspective
  - **Intermediate:** The criteria on which subsequent elements depend
  - **Lower:** A set of alternatives
- Construction of a set of pair-wise matrices
- Use the compared priorities to provide weight for the level immediately below and obtain the overall global priority

AHP has been widely used as a useful approach that is more explanatory, reliable and accurate than other weighting techniques while providing methods to check the data consistency by the decision makers (Yang & Huang 2000). The technique quantifies subjective factors which may otherwise prove challenging (Figueira *et al.*

2005). However, the number of pairwise comparisons may be very large as they depend on the number of factors which may increase substantially as well.

### 6.3.2 Using AHP for calculating RCs weights in CMRA

Because CMRA RCs are subjective and difficult to quantify, the AHP mechanism is used. It provides a mechanism to measure both subjective and objective factors (Saaty, 2008). In this CMRA research instrument, there are six RC. Hence, it is very useful to visualise the problem by structuring it as a hierarchy in the AHP approach.

In the current context, the AHP is used first to calculate the weight of each RC and then aggregate the scores to obtain the final readiness score for the university's result. This can be done by conducting pairwise comparison between the RCs to rank and prioritise the importance of each against the other. No pair comparisons were used to rank the PQs associated with each RC; the score of each PQ has the same weight. An example of the ratio scale used to conduct the pairwise comparison between the 6 RCs is shown in Figure 6-3. The comparison scale is adopted from (Saaty, 2008). Although the scale levels seems confusing as the word "more " is not introduced in the scale for each level, it was explained verbally during the conduction of the focus group sessions in the three universities.

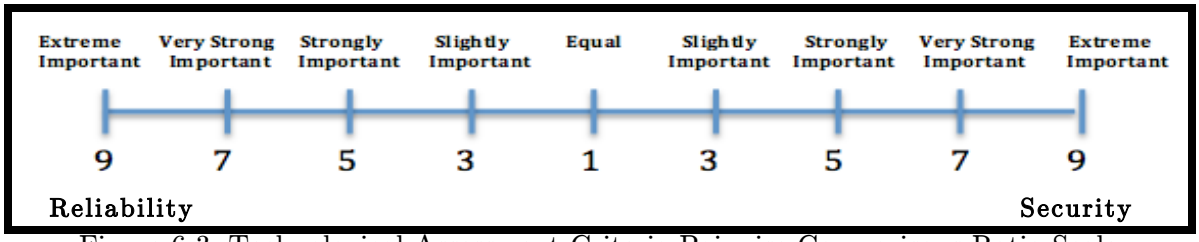


Figure 6-3: Technological Assessment Criteria Pairwise Comparisons Ratio Scale

In CMRA there are two domains the Technological, which includes three RCs – Security, Interoperability and Reliability; and the Organisational domain, which includes SLA Requirements, Migration Plan and Compliance with the Regulations.

In AHP, to conduct the pair comparison, the number of comparison is calculated as follows:

$$N = \frac{n(n-1)}{2} \quad (1)$$

In (1), $N$ is the number of pair-wise comparisons and $n$ is the number of factors.

Applying Equation (1) to CMRA results in two separate 3 x 3 matrices – one for the organisational domain and the other for the technological domain. Hence, for $n = 3$ total number of pair comparisons are calculated as follows:

$$N = \frac{3(3-1)}{2} = \frac{6}{2} = 3 \quad (2)$$

An example of the matrix equation of AHP pair comparison for the technological domain in CMRA is shown in Figure 6-4. The numbers in the figure are derived from one of the participants' judgments taken from the University-A Case Study:

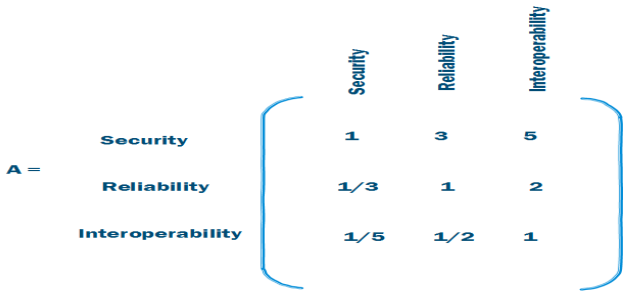


Figure 6-4: Example of AHP Matrix

As shown in the reciprocal 3 x 3 matrix in Figure 6-4, the diagonal elements of the matrix are always one whereas the values on the right are the actual judgement values and those on the left side are the reciprocal values. Comparing Security and Reliability gives a 'Slightly Important' tendency to Security over Reliability which is equal to 3. On the other hand, comparing Reliability to Security gives a reciprocal value of 1/3. Moreover, it must be noticed that all the elements in the matrix are positive, or $a_{ij} > 0$. Based on the square matrix in Figure 6-4 we can obtain the Eigenvalue and Eigenvector (Yang & Huang, 2000). The Eigenvector gives the priority ordering of the criteria and the eigenvalue measures the consistency of the matrix (Yang and Huang, 2000).

Now there is a comparison matrix, the priority vector is computed, which is the normalised Eigen vector of the matrix. The priority vector is calculated first by summing-up the column-wise values of the matrix shown in Figure 6-5. The steps to calculate the relevant 3 x 3 matrix's left principle Eigen vector are given below:

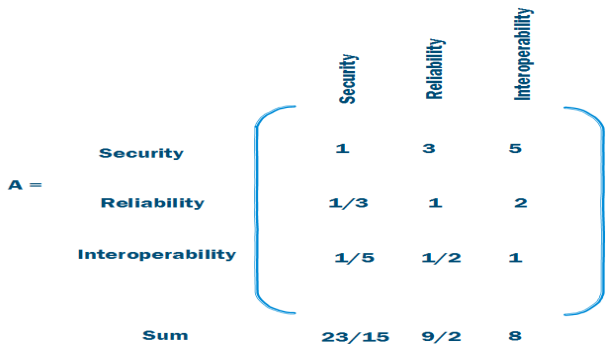


Figure 6-5: Reciprocal matrix column summation

Now, each element of the matrix is divided by the sum of its column. Then, each element of the matrix is divided by the sum of its column to have a normalised

relative weight generating the sum of each column to be 1, as illustrated below in Figure 6-6.


Figure 6-6: Matrix Columns Normalised Relative Weights

Finally, the normalised Eigen vector (priority vector) is obtained by averaging across the rows, as in Figure 6-7.

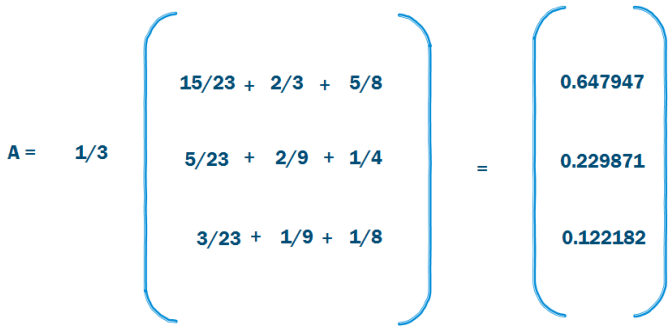


Figure 6-7: Normalised Principle Eigen Vector

Hence, in the example above, the priority Eigen vector shows the relative weights. For example, Security is 64.8%, Reliability is 23% and Interoperability is 12.2%. Hence, Security is the most important aspect. In this case, we know more than their ranking in fact, the relative weight is the ratio scale. For instance, Security is 2.8 (0.64/0.23) times more important than Reliability. The priority Eigen vector is calculated again by squaring the normalised matrix to check the similarity between the resultant priority Eigen Vector from the square matrix to the one generated from the normalised matrix. The process of squaring the matrix is iterated until the difference between the last resultant Eigen vector is neglected or equal to the iteration before. In this example, the final Eigen Vector was reached in the third iteration.

Aside from the usual comparison, to evaluate the consistency of these answers, the principle Eigen value is to be calculated. Consistency is closely related to the transitive property where, for instance, if $Security \succ Reliability$ and $Reliability \succ Interoperability$, then $Security \succ Interoperability$. Hence, if Security is more important than Reliability and Reliability is more important than Interoperability then Security, logically, is more important than Interoperability.

Saaty (2008) provided a consistent reciprocal matrix approach where the largest Eigen value (principal Eigen value) is equal to the number of comparisons, or $\lambda_{max} = N$ where $N$ is the number of comparisons. For instance, as given in Figure 6-5, this value is calculated by obtaining the summation of each column multiple by the Normalised Principle Eigen Vector calculated in Figure 6-7.

$$\lambda_{max} = \frac{23}{15}(0.6479) + \frac{9}{2}(0.2298) + 8(0.122) = 0.9962 + 1.0341 + 0.976 = 3.0063 \quad (3)$$

After obtaining $\lambda_{max}$, the measure of consistency (Consistency Index) is calculated using the following formula:

$$CI = \frac{\lambda_{max} - N}{N-1} \quad (4)$$

Based on the value of $\lambda_{max}$ from the previous example and three comparisons N=3, the consistency index value is:

$$CI = \frac{\lambda_{max-N}}{N-1} = \frac{3.006-3}{3-1} = 0.003 \quad (5)$$

Based on the calculated CI, Saaty (2008) proposed a technique to use this index by comparing it with the Random Consistency Index (RI). To ensure the consistency and the accuracy of the individual judgments, Saaty (2008) randomly generated a reciprocal matrix via a scale $\frac{1}{9}, \frac{1}{8} \ldots \frac{1}{2}, 1, 2 \ldots 8, 9$ to obtain the RI and compare it with CI to check if it is approximately 10% or less. If the Consistency Ratio (CR) is not less than 10%, the problem should be studied and the judgements should be revised. The average RI of a sample size with 500 matrices is shown in Table 6-8 where (N = number of comparisons).

Table 6-8: The Random Consistency Index (RI)

| N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0 | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

Finally, to compare the CI with RI, the following equation can be used:

$$CR = \frac{CI}{RI} = \frac{0.003}{0.58} = 0.00517 = 0.5\% < 10\% \quad (6)$$

Since the CR is less than 10%, the subjective judgment in the example provided is consistent and hence there is no need to revise the judgement.

All the steps above were to calculate the AHP judgment for one participant. In order to calculate multiple judgments, the arithmetic and geometric means are widely used (Forman and Peniwati, 1998). When calculating the average of judgements, which is either arithmetic or geometric, the individual judgments are treated as of equal importance (Ramanathan and Ganesh, 1994).

### 6.3.3 Calculating the final score in CMRA

After ranking the RCs in each domain as in section 6.3.2, each domain's pairwise comparison will be calculated separately because it is very confusing for the participants to be asked to compare the importance of security, which is a technology-related RC with a migration plan, which pertains to the organisational domain. The final weight for the overall score consists of the average of the two domains. The calculations of CMRA weights are as follow:

- Firstly, the weight of each RC in the technological domain is calculated. Then, the overall score of the domain is provided:
  - **Reliability score (%) =** (average (PQ1 + …. PQ5 scores))* AHP weight.
  - **Security score (%) =** (average (PQ1 + …. PQ13 scores)) * AHP weight.
  - **Interoperability AHP weight (%) =** (average (PQ1 + …. PQ7 scores)) * AHP weight.
  - **Technological domain score (100%) =** Reliability score (%) + Security score (%) + Interoperability score (%).
- Secondly, the weight of each RC in the organisational domain is calculated. Then, the overall score of the domain is provided:
  - **SLA Requirements score (%)** = (average (PQ1 + …. PQ8 scores)) * AHP weight.
  - **Migration plan score (%) =** (average (PQ1 + …. PQ6 scores)) * AHP weight.
  - **Compliance with regulation score (%) =** (average (PQ1 + …. PQ5 scores)) * AHP weight.
  - **Organisational domain score (100%) =** SLA Requirements score (%) + Migration Plan score (%) + Compliance with regulation score (%).
- Finally, the total score of CMRA at University X which represents its final readiness score, is calculated as:
  - **The CMRA final score in University X (100%) =** Average (Technological domain score (100%) and Organisational domain score (100%).

Similar to the results' indication of the processes' final score (as shown in section 6.1.3), and by following PAM and ISO/IEC 15504-5:2012 score indications, the interpretation of the CMRA final score for each university is fallen under the following categories:

- **Any score from 0% to 12.5% indicates:** severe lack of readiness - There are major issues and weakness areas and serious consideration is required before migrating to the cloud.
- **Any score from 12.51% to 37.5% indicates:** Below-Average Readiness– Major, timely improvements are needed before migrating your systems to the cloud.
- **Any score from 37.51% to 62.50% indicates:** Average Readiness – considerable improvements are needed *for* successful cloud migration project.
- **Any score from 62.51% to 87.50% indicates:** Solid Readiness – Minor improvements are needed to bring the readiness score to the successful readiness level for cloud migration.
- **Any score from 87.51% to 100% indicates:** Optimized Readiness – no action needs to be taken before considering the cloud migration project.

The calculations of the above score ranges are made based on averaging the values of each level with the consecutive one in the five level scales above.

## 6.4 Chapter Summary

The chapter discussed the four CMRA development stages, which started with the GQM approach to building the instrument. Each of the readiness criteria was represented on a template showing the issues that measure readiness criteria. In the second stage, the metrics in the CMRA instrument were based on the COBIT5's scale of PAM.

The third stage was the validation phase of the CMRA instrument's content and validity. This was undertaken by interviewing six individual experts from various IT domains. The fourth and final stage of the development included the weighting calculation of the CMRA instrument resulting from the AHP technique. The AHP technique was only used to weigh the priorities of the RCs. RCs in the technological domain were pair-compared separately from those in the organisational domain. Hence, the overall readiness score was calculated as an average of the technological and organisational domain scores.

# Chapter 7

# Case Studies

This chapter discusses the case studies and experimental results to demonstrate the CSFs for the Cloud Migration framework **(SFCM 2)** and its CMRA Instrument. They were conducted to understand the usefulness of the CMRA instrument, and examine its practicality and applicability. The chapter analyses case studies in three Saudi universities.

These universities are referred to as University-A, -B and -C to meet the confidentiality agreement. The data presented in this chapter is used to show the Readiness score relating to each university for cloud migration. The feedback about the CMRA instrument was collected and used as a practicality test. The research questions to be answered in this chapter are **RQ2.2** (Based on the Saudi university requirements, what is the importance/priority of each of the readiness criteria in the proposed instrument?) and **RQ2.3** (How good is the functionality and practicality of the CMRA instrument?)

## 7.1 CMRA Assessment Process and Case Studies' Result

The final version of the CMRA instrument is shown in Table 7-1, and was used to assess Saudi universities' readiness for cloud migration. The case studies were conducted to evaluate the practicality of the proposed instrument. The instrument has two domains: the technological comprises three RCs – Reliability, Security and Interoperability; and the organisational comprises the SLA Requirements, the Migration Plan and Compliance with Regulations. The instrument was converted to an online survey via the iSurvey[2] portal. The online version of the final CMRA instrument is provided as Appendix E.

The CMRA instrument's objective is to measure the preparedness of universities for moving from traditional ICT to cloud-based services. The instrument measures subjective judgements of readiness for the evaluated universities. The judgements are collected from IT personnel in the university's IT deanship.

[2] https://www.isurvey.soton.ac.uk

Table 7-1: Final version of CMRA instrument

| **Technological domain** | | |
|---|---|---|
| **Readiness Criteria (RC)** | Measuring processes (P) | Aggregation |
| **Reliability** | Bandwidth (BW)<br>Disaster recovery (DR)<br>Availability (AV)<br>Data Latency (DL) | $S_T = \sum_{i=1}^{n} \left( \frac{\sum_{j=1}^{m} p_{ij}}{m} * w_{ij}^{AHP} \right)$<br>Where $S_T$ is the final domain score, $n = 3$ is the number of RC, $m$ is the number of Ps for each RC and $w_{ij}^{AHP}$ is the AHP weight calculated for each RC |
| **Security** | Privacy (PV)<br>Confidentiality (CF)<br>Integrity (INT)<br>Non-repudiation (NR)<br>Security Awareness & Practice (SA)<br>Physical Security (PS)<br>Security Auditing (SD)<br>Malicious Detection (MD) | |
| **Interoperability** | Portability (PT)<br>Interoperability Awareness & Practices (IP)<br>Extensibility (EX) | |
| **Organisational domain** | | |
| **SLA Requirements** | Technical support level (TS)<br>Arabic language support (AL)<br>Service level requirements (SL)<br>Cost requirements (CR)<br>Penalties (PN)<br>Security Requirements (SR) | $S_O = \sum_{i=1}^{n} \left( \frac{\sum_{j=1}^{m} p_{ij}}{m} * w_{ij}^{AHP} \right)$<br>Where $S_O$ is the final domain score, $n = 3$ is the number of RC, $m$ is the number of Ps for each RC and $w_{ij}^{AHP}$ is the AHP weight calculated for each RC |
| **Migration Plan** | Knowledge-base (KB)<br>IT staff training (ST)<br>Management support (MS)<br>Performance assessment (PA) | |
| **Compliance with Regulations** | Degree of data control (DC)<br>Adherence to local regulations (LR)<br>Data usage policies (DP) | |
| **Aggregation method for CMRA instrument's final score** | | |
| $$\boldsymbol{CMRA = \frac{S_O + S_T}{2}}$$ | | |

Figure 7-1 illustrates the readiness assessment framework used to evaluate the maturity of a university IT infrastructure to enable it to migrate to the cloud. The subjective assessment process includes two dimensions that cover various technological and organisational aspects. The technological factors are related to the cloud architecture and service quality decision-making, while the organisational factors cover the human factors and cultural practices of the universities.

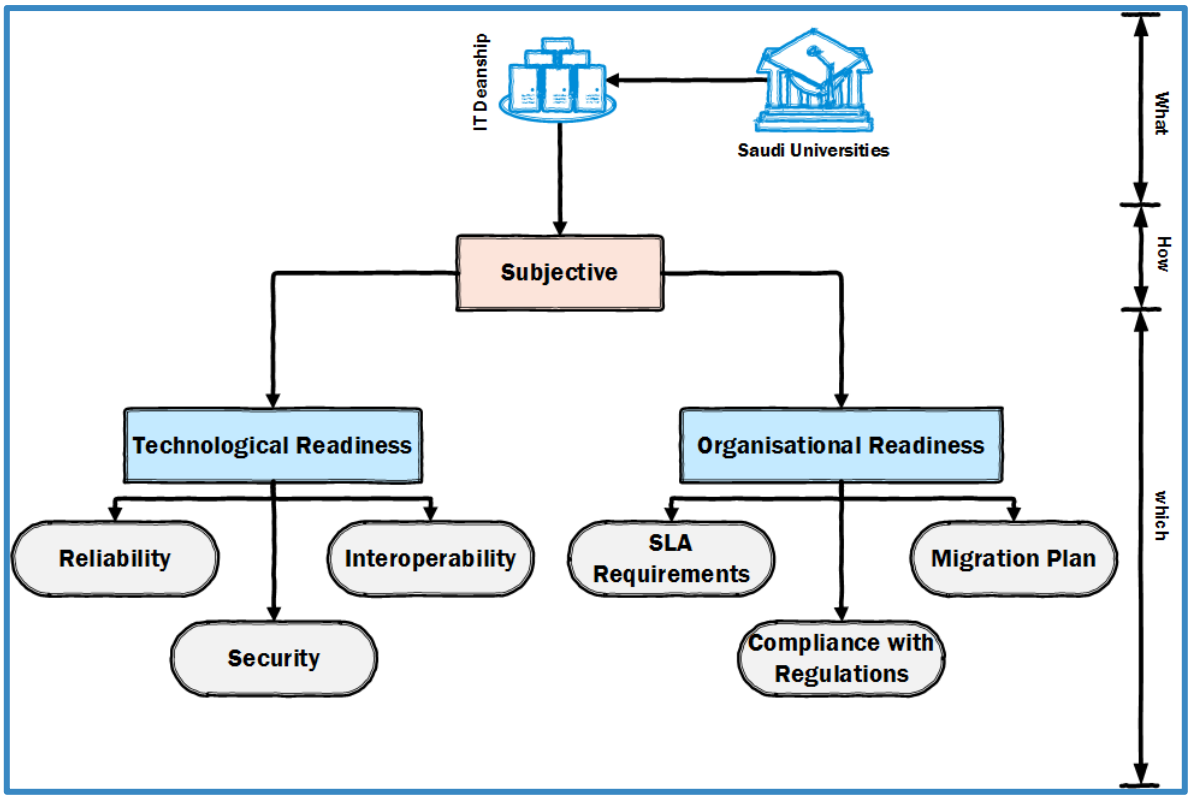


Figure 7-1: Overview of the Process for Applying the CMRA Instrument

The next sections present the participants' perceptions of issues related to cloud migration and potential future cloud services that the university will deploy, then three separate case studies at three selected universities. Each section of the three case studies is organised into bulleted points describing the outcome of the case studies, the analyses and the discussion of the study.

The first results presented are the AHP pairwise comparison results for each university. A report was presented to the university, based on the results in a tabular summarisation of the CMRA instrument components, including the RC scores, PQ scores and the whole cloud readiness score for the university. In the analysis section, the radar chart of the categories was presented exactly as shown in the report provided for the university.

### 7.1.1 Participants' perception of cloud migration issues

At the start of applying the CMRA instrument for each university, the participants were asked questions to measure their perceptions of their university's

preparedness for cloud migration. Participants from the three universities responded to questions aimed at obtaining their perceptions about various cloud migration-related issues (Figure 7-2), covering the participant confidence level, the perceived benefits and challenges of cloud migration and the sources that they relied on to prepare for the cloud migration. In Figure 7-2 (a), two-thirds of respondents agreed with the confidence of their university regarding readiness for cloud migration. In (b), the participants most perceived cloud benefit was access to the latest technology and IT services Scalability.

In (c), the top challenge was the lack of cloud-related knowledge with 31%, whereas the process of selection of cloud provider was considered the least challenging at 9%. In (d), around 50% of the respondents, vendor offers were the primary source of information they used for cloud migration preparation whereas expert reviews were neglected during the university's preparation.

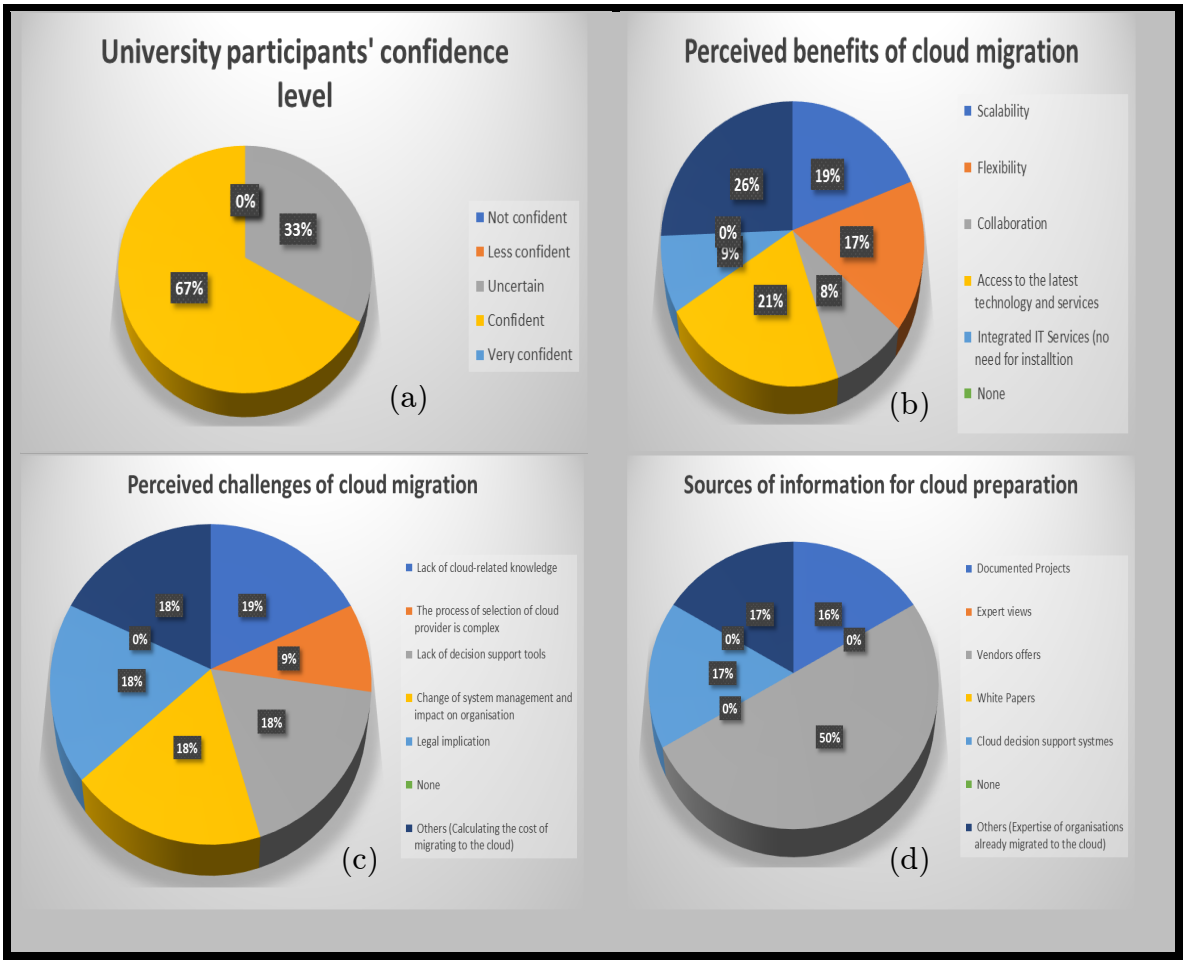


Figure 7-2: Universities' perception on cloud migration

### 7.1.2 Potential cloud services to be deployed in the universities

Table 7-2 summarises leading providers of technologies and cloud services for the applications and services nominated to be deployed when the university ICT are migrated to the cloud by the focus group participants in the three case studies conducted.

The aim of providing this information is to provide them with a list of the well-known cloud providers for the services chosen in order to consider them in further investigations of suppliers for future development of IT services for the university.

Table 7-2: Cloud services and potential providers.

| Service Name | Technology Provider | Cloud Provider |
|---|---|---|
| **IaaS Services** | | |
| **Enterprise Storage** | EMC2,NetApp, IBM, Hitachi | Amazon WS, Google, MS Azure |
| **Server Visualisation** | VM-ware, MS-Hyper-V | Telco-providers, Rackspace |
| **Remote Access/Virtual Desktop** | Citrix, MS Remote Desktop | Rackspace, CobWeb, Nasstar |
| **PaaS Services** | | |
| **Database** | Oracle, DB2 | Amazon-WS, ORACLE, Rackspace |
| **Service Management** | BMC Remedy, Autotask | BMC, CA Technologies |
| **Enterprise Resource Planning** | Oracle, SAP | No Famous Cloud Solution Yet |
| **SaaS Services** | | |
| **Intranet** | MS WebServer, Unix/Linux | Google, ISP's, Telco-providers |
| **.net Apps** | Microsoft | Rackspace |
| **CRM** | SAP, Oracle | SalesForce |

### 7.1.3 University-A case study findings and discussions

This case study was conducted in a Saudi government university with about 25,000 students and employees. The university was established three years ago and is considered a start-up under the definition of higher education in Saudi Arabia, which indicates that each university under the age of 10 years is to be termed a start-up institution. The participants in the case study were IT experts and specialists in the deanship of IT. As discussed in section 4.4, each case study's participants were classified into Groups A and B. The profiles of the participants nominated in University-A case study are illustrated in Table 7-3.

Table 7-3 Participants' Profiles

| University A Case Study Participants Profiles | |
|---|---|
| **Years of Expertise** | **Job Role** |
| **Group-A.A Participants** | |
| **4 years** | IT Systems Administrator |
| **6 years** | Network engineer |
| **4 years** | Infrastructure and Servers Specialist |
| **7 years** | Applications Department Manger |
| **Group-B.A Participants (Seniors)** | |
| **10 years** | **A:** Senior Networks Engineer and Head of Network Department |
| **12 years** | **B:** Dean of IT deanship - IT Project Manager |

The university started a cloud migration project with a local telecommunication company named Saudi Telecom Company (STC). However, the project is still in the early stages. The underlying reason for its selection was due to the participants confirming that they are migrating to the cloud within a year as illustrated in the confirmatory study in Figure 5-2 part (D).

Each section, given below, of this study is organised into separate bulleted points describing the analysis and the discussion of the study where the first result presents the AHP pairwise comparison, then the result of the readiness status is examined and eventually the findings are presented. Based on the result, a report was presented to the university. Full details of the results of this report are presented in Appendix G.

After Group-A.A participants evaluated their readiness for cloud migration, they were asked to weight and prioritise the importance of each of the readiness criteria in the CMRA instrument according to their opinion and their university practices. The comparison was conducted using AHP technique as detailed in the calculation given in section 6.3.2. The final weights for each of the six assessment criteria are presented in the matrix in Table 7-4.

Table 7-4: Aggregated Weights of Group A.A Participants for RCs importance

| Technological Readiness Criteria | | | | |
|---|---|---|---|---|
| | Security | Interoperability | Reliability | Weights (%) |
| **Security** | 1 | 3 | 3 | 59.4 |
| **Interoperability** | 1/3 | 1 | 1/2 | 15.7 |
| **Reliability** | 1/3 | 2 | 1 | 24.9 |
| **Organisational Readiness Criteria** | | | | |
| | SLA Requirements | Migration Plan | Compliance with Regulations | Weights (%) |
| **SLA Requirements** | 1 | 1 | 1 | 33.3 |
| **Migration Plan** | 1 | 1 | 1 | 33.3 |
| **Compliance with Regulations** | 1 | 1 | 1 | 33.3 |

- **Results of University-A Readiness Status**

The readiness score for each RC in CMARA University-A resulted from focus group analysis of participants' university current status, as illustrated in Table 7-5 for the technological RCs and Table 7-6 for the organisational RCs.

Table 7-5: University-A Results for the Technological Domain

| RC No | RC Title | PQ No | PQ Title | Readiness Score (%) |
|---|---|---|---|---|
| 1 | **Reliability (RE)** Weighted Readiness Score: **11.2%** | 1 | System workload spike time identification | 50 |
| | | 2 | Up-time for the IT services | 100 |
| | | 3 | Data latency assessment | 0 |
| | | 4 | Network bandwidth | 50 |
| | | 5 | Provision of recovery techniques | 25 |
| 2 | **Security (SE)** Weighted Readiness Score: **30.84%** | 1 | Information security standards adoption | 50 |
| | | 2 | Malicious activities control | 75 |
| | | 3 | Non-repudiation controls | 25 |
| | | 4 | Integrity controls | 75 |
| | | 5 | Access lists | 100 |
| | | 6 | Authentication capability | 75 |
| | | 7 | Security auditing | 75 |
| | | 8 | Documentation of security policies | 50 |
| | | 9 | Privacy controls requirements | 75 |
| | | 10 | Evaluating data centre protection | 0 |
| | | 11 | Security-driven cloud-model selection | 0 |
| | | 12 | Critical IT categorisation | 50 |
| | | 13 | Cloud security risks awareness | 25 |
| 3 | **Interoperability (IN)** Weighted Readiness Score: **4.48%** | 1 | Identifying legacy systems special requirements | 25 |
| | | 2 | Scaling out application architecture | 75 |
| | | 3 | Evaluation SOA design in applications | 25 |
| | | 4 | Enterprise service bus | 0 |
| | | 5 | Awareness of application interoperability standards | 0 |
| | | 6 | Application interoperability status identification | 50 |
| | | 7 | Data portability evaluation | 25 |
| **Total Technological RCs obtained readiness score (%)** | | | | 46.52% |

Table 7-6: University-A Results for the Organisational Domain

| RC No | RC Title | PQ No | PQ Title | Readiness Score (%) |
|---|---|---|---|---|
| 1 | **SLA-Requirements (SL)** Weighted Readiness Score: **12.48%** | 1 | Exit procedures and clauses definition | 0 |
| | | 2 | Existence of cloud RFP document | 50 |
| | | 3 | Cost requirements for migrated services | 25 |
| | | 4 | Document of compensation and remedy | 25 |
| | | 5 | Service customisation requirements | 50 |
| | | 6 | Documentation and technical support | 75 |
| | | 7 | Customisation of security requirements | 25 |
| | | 8 | Identifying the service level required for the migrated services | 50 |
| 2 | **Migration Planning (MP)** Weighted Readiness Score: **9.7125%** | 1 | Top management support for the cloud migration | 75 |
| | | 2 | Migrated services impact assessment | 25 |
| | | 3 | Identifying IT skills required | 25 |
| | | 4 | Building cloud knowledgebase | 25 |
| | | 5 | Including stakeholders in service readiness assessment | 0 |
| | | 6 | Strategic plans for cloud in IT strategy | 25 |
| 3 | **Compliance with regulations (CR)** Weighted Readiness Score: **13.32%** | 1 | Sensitive data regulation requirements | 25 |
| | | 2 | Alignment with government legal and regulatory requirements | 50 |
| | | 3 | Identifying providers licensed by the government | 50 |
| | | 4 | Existence of cloud ownership policies | 0 |
| | | 5 | Awareness of local regulations on cloud usage | 75 |
| **Total Organisational RCs obtained readiness score (%)** | | | | 35.52%. |

- **University-A PQs Status analysis**

The processes readiness status of each RC is grouped on the basis of its level in the table 7-7.

Table 7-7: University-A PQs Status Analysis

| RC status | RC abbreviation | PQ No | PQ title |
|---|---|---|---|
| Excellent Areas (100%) | IR | 1 | Up-time for the IT services |
| | SP | 1 | Access lists |
| Good Areas (75%) | SP | 1 | Malicious activities control |
| | | 2 | Integrity controls |
| | | 3 | Authentication capability |
| | | 4 | Security auditing |
| | | 5 | Privacy controls requirements |
| | SI | 1 | Scaling out application architecture |
| | SLA | 1 | Documentation and technical support |
| | MP | 1 | Top management support for the cloud migration |
| | CR | 1 | Awareness of local regulations on cloud usage |
| Adequate Areas (50%) | IR | 1 | System workload spike time identification |
| | | 2 | Network bandwidth |
| | SP | 1 | Information security standards adoption |
| | | 2 | Documentation of security policies |
| | | 3 | Critical IT categorisation |
| | SI | 1 | Application interoperability status identification |
| | SLA | 1 | Existence of cloud RFP document |
| | | 2 | Service customisation requirements |
| | | 3 | Identifying the service level required for the migrated services |
| | CR | 1 | Alignment with government legal and regulatory requirements |
| | | 2 | Identifying providers licensed by the government |
| Marginal Areas (25%) | IR | 1 | Provision of recovery techniques |
| | SP | 1 | Non-repudiation controls |
| | | 2 | Cloud security risks awareness |
| | SI | 1 | Identifying legacy systems special requirements |
| | | 2 | Evaluation SOA design in applications |
| | | 3 | Data portability evaluation |
| | SLA | 1 | Cost requirements for migrated services |
| | | 2 | Document of compensation and remedy |
| | | 3 | Customisation of security requirements |
| | MP | 1 | Migrated services impact assessment |
| | | 2 | Identifying IT skills required |
| | | 3 | Building cloud knowledgebase |
| | | 4 | Strategic plans for cloud in IT strategy |
| | CR | 1 | Sensitive data regulation requirements |
| Inappropriate Areas (0%) | RI | 1 | Data latency assessment |
| | SP | 1 | Evaluating data centre protection |
| | | 2 | Security-driven cloud-model selection |
| | SI | 1 | Enterprise service bus |
| | | 2 | Awareness of application interoperability standards |
| | SLA | 1 | Exit procedures and clauses definition |
| | MP | 1 | Including stakeholders in service readiness assessment |
| | CR | 1 | Existence of cloud ownership policies |

- **University-A Readiness Criteria Analysis**

The Radar Chart in Figure 7-3 illustrates the University-A's scores against each of these RC. The University-A achieved scores for each of the RCs, as described further in the points given below:

- **Good Areas:**
  - Security – 52%

**Action required:** *'The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration'*

- **Adequate Areas:**
  - Reliability – 45%:
  - Compliance with Regulations – 40%
  - SLA Requirements – 38%
  - Interoperability – 29%
  - Migration Planning – 29%

**Action Required:** *'The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration'*

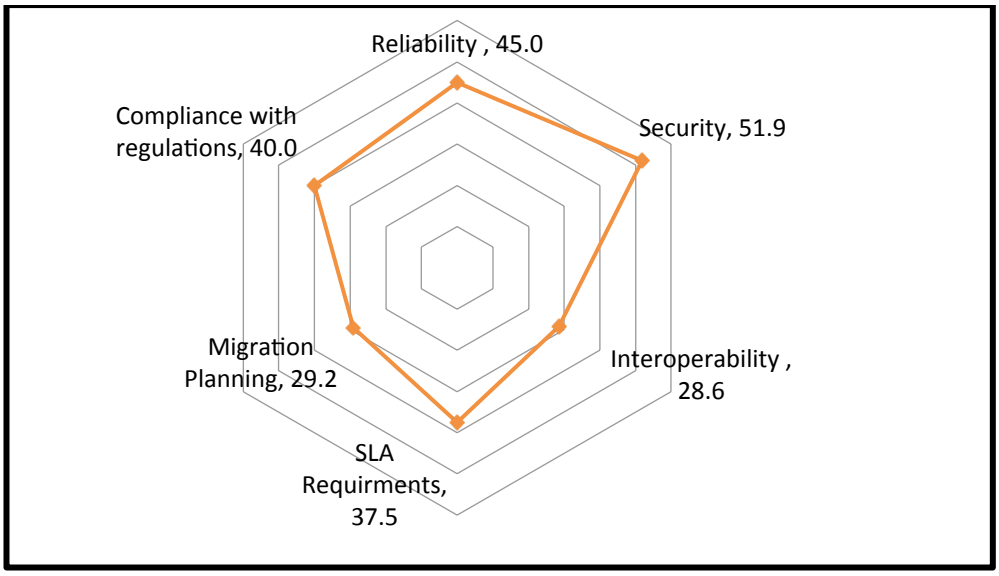


Figure 7-3: Analysis of University-A various RC scores achieved

- **Discussion of University-A results**

In response to the status of some processes, University-A showed two processes under the 'optimised' level of process maturity. These are 'Up-time for the IT services' and managing the 'Access list'. The Up-time for the IT Service for University-A had a 100% (optimised) score, which is further elaborated by the

respondents' comments that indicate the use of specialised monitoring packages such as HP OpenView to monitor the whole IT infrastructure network. Similarly, 11 of the processes were in the 50% (defined) maturity level which, for one of these 'Network bandwidth' calculation, is confirmed by respondents' comments indicating that most of such calculations within the IT deanship were manual and prioritised higher bandwidth for the university main branch than others. Moreover, 14 processes were in the 25% (initial) process level. This is further confirmed for the 'Identifying IT skills' process, indicating that they do not lend much importance to this aspect, since full technical support is promised by the local cloud providers.

The majority of RC statuses in University-A are either 'Good Areas' or 'Adequate Areas' as discussed above. For security practices in the university, the score was in the 'Good Area' range with 52%. Moreover, the lowest scores belonged to Interoperability and Migration Planning, at 29% each. Based on the readiness assessment of all the assessment criteria, the overall readiness score percentage for University-A for Technological Readiness was 46.5% and for Organisational Readiness 35.5%. Hence, the overall score for University-A readiness is **41%** thereby giving the following required action:

> ***'Average level of readiness for cloud migration,*** **considerable improvements are needed for successful cloud migration project'**

### 7.1.4 University-B case study findings and discussions

The case study is applied to a Saudi government university with about 75000 students and employees. The university was established eight years ago and is considered a start-up as per the definition of Higher Education of Saudi Arabia, which indicates that each university under the age of 10 years is to be termed a start-up institution. The participants in the case study were IT experts and specialists working in the Deanship of IT. The participated IT personnel profiles are depicted in Table 7-8. For full details about the results presented to the university see Appendix H.

Table 7-8: Participants' Profiles

| University-B Case Study Participants Profiles | |
|---|---|
| **Years of Expertise** | **Job Role** |
| **Group-A.B Participants** | |
| **7 years** | IT Security Engineer |
| **6 years** | Network Security Engineer |
| **4 years** | IT Software Engineer |
| **3 years** | IT Application Support |
| **Group-B.B Participants (Seniors)** | |
| **11 years** | **A:** Senior Head of Programming and web development depts. |
| **14 years** | **B:** Vice Dean of IT deanship - IT System administrator |

The university still has not migrated to the cloud yet. However, they were approached by Microsoft cloud team in the Middle East branch in Riyadh and they proposed to establish a cloud beta project for the university. They still studying the offer proposed and have not decided about it so far. The underlying reason of selection of this university was the same as in the previous case which is the intention of the university for migrating to the cloud diagram within one year.

- **University-B AHP Weights for the RCs**

Table 7-9: Aggregated weights of Group A.B RCs importance

| **Technological Readiness Criteria** | | | | |
|---|---|---|---|---|
| | Security | Interoperability | Reliability | Weights (%) |
| **Security** | 1 | 7 | 6 | 76 |
| **Interoperability** | 1/7 | 1 | 2 | 14.4 |
| **Reliability** | 1/6 | 1/2 | 1 | 9.6 |
| **Organisational Readiness Criteria** | | | | |
| | SLA Requirements | Migration Plan | Compliance with Regulations | Weights (%) |
| **SLA Requirements** | 1 | 2 | 1 | 38.7 |
| **Migration Plan** | 1/2 | 1 | 1/3 | 16.9 |
| **Compliance with Regulations** | 1 | 3 | 1 | 44.3 |

- **The results of the University-B readiness status**

The readiness score for each RC the university-A scored as resulted from participants' focus group analysis are illustrated in Table 7-10 for the technological RCs and 7-11 for organisational RCs.

Table 7-10: University-B readiness score results for the technological domain

| RC No | RC Title | PQ No | PQ Title | Readiness Score (%) |
|---|---|---|---|---|
| 1 | **Reliability (RE)** Weighted Readiness Score: **5.76%** | 1 | System workload spike time identification | 100 |
| | | 2 | Up-time for the IT services | 75 |
| | | 3 | Data latency assessment | 50 |
| | | 4 | Network bandwidth | 0 |
| | | 5 | Provision of recovery techniques | 75 |
| 2 | **Security (SE)** Weighted Readiness Score: **59.92%** | 1 | Information security standards adoption | 50 |
| | | 2 | Malicious activities control | 100 |
| | | 3 | Non-repudiation controls | 100 |
| | | 4 | Integrity controls | 100 |
| | | 5 | Access lists | 100 |
| | | 6 | Authentication capability | 100 |
| | | 7 | Security auditing | 100 |
| | | 8 | Documentation of security policies | 25 |
| | | 9 | Privacy controls requirements | 100 |
| | | 10 | Evaluating data centre protection | 75 |
| | | 11 | Security-driven cloud-model selection | 25 |
| | | 12 | Critical IT categorisation | 100 |
| | | 13 | Cloud security risks awareness | 50 |
| 3 | **Interoperability (IN)** Weighted Readiness Score: **6.68%** | 1 | Identifying legacy systems special requirements | 100 |
| | | 2 | Scaling out application architecture | 100 |
| | | 3 | Evaluation SOA design in applications | 75 |
| | | 4 | Enterprise service bus | 0 |
| | | 5 | Awareness of application interoperability standards | 0 |
| | | 6 | Application interoperability status identification | 25 |
| | | 7 | Data portability evaluation | 25 |
| **Total Technological RCs obtained readiness score (%)** | | | | 76.67% |

Table 7-11: University-B readiness score results for the technological domain

| RC No | RC Title | PQ No | PQ Title | Readiness Score (%) |
|---|---|---|---|---|
| 1 | **SLA-Requirements (SL)** Weighted Readiness Score: **18.14%** | 1 | Exit procedures and clauses definition | 0 |
| | | 2 | Existence of cloud RFP document | 75 |
| | | 3 | Cost requirements for migrated services | 25 |
| | | 4 | Document of compensation and remedy | 25 |
| | | 5 | Service customisation requirements | 50 |
| | | 6 | Documentation and technical support | 100 |
| | | 7 | Customisation of security requirements | 50 |
| | | 8 | Identifying the service level required for the migrated services | 25 |
| 2 | **Migration Planning (MP)** Weighted Readiness Score: **5.63%** | 1 | Top management support for the cloud migration | 50 |
| | | 2 | Migrated services impact assessment | 50 |
| | | 3 | Identifying IT skills required | 25 |
| | | 4 | Building cloud knowledgebase | 25 |
| | | 5 | Including stakeholders in service readiness assessment | 25 |
| | | 6 | Strategic plans for cloud in IT strategy | 25 |
| 3 | **Compliance with regulations (CR)** Weighted Readiness Score: **13.29%** | 1 | Sensitive data regulation requirements | 25 |
| | | 2 | Alignment with government legal and regulatory requirements | 50 |
| | | 3 | Identifying providers licensed by the government | 50 |
| | | 4 | Existence of cloud ownership policies | 0 |
| | | 5 | Awareness of local regulations on cloud usage | 25 |
| **Total Organisational RCs obtained readiness score (%)** | | | | 47.87% |

- **University-B PQs Status analysis**

The processes readiness status for each RC are grouped based on its status level in Table 7-12:

Table 7-12: University-B PQs status Analysis

| RC status | RC abbreviation | PQ No | PQ title |
|---|---|---|---|
| Excellent Areas (100%) | RE | 1 | System workload spike time identification |
| | IN | 1 | Identifying legacy systems special requirements |
| | | 2 | Scaling out application architecture |
| | SL | 1 | Documentation and technical support |
| | SE | 1 | Privacy controls requirements |
| | | 2 | Malicious activities control |
| | | 3 | Non-repudiation controls |
| | | 4 | Integrity controls |
| | | 5 | Access lists |
| | | 6 | Authentication capability |
| | | 7 | Security auditing |
| | | 8 | Critical IT categorisation |
| Good Areas (75%) | RE | 1 | Up-time for the IT services |
| | | 2 | Provision of recovery techniques |
| | SE | 1 | Evaluating data centre protection |
| | IN | 1 | Evaluation SOA design in applications |
| | SL | 1 | Existence of cloud RFP document |
| Adequate Areas (50%) | RE | 1 | Data latency assessment |
| | | 2 | Network bandwidth calculations |
| | SE | 1 | Information security standards adoption |
| | | 2 | Cloud security risks awareness |
| | IN | 1 | Application interoperability status identification |
| | SL | 1 | Service customisation requirements |
| | | 2 | Customisation of security requirements |
| | CR | 1 | Alignment with government legal and regulatory requirements |
| | | 2 | Identifying providers licensed by the government |
| Marginal Areas (25%) | SE | 1 | Documentation of security policies |
| | | 2 | Security-driven cloud-model selection |
| | IN | 1 | Application interoperability status identification |
| | | 2 | Data portability evaluation |
| | | 3 | Customisation of security requirements |
| | SL | 1 | Cost requirements for migrated services |
| | | 2 | Document of compensation and remedy |
| | | 3 | Identifying the service level required for the migrated services |
| | MP | 1 | Identifying IT skills required |
| | | 2 | Building cloud knowledgebase |
| | | 3 | Including stakeholders in service readiness assessment |
| | | 4 | Strategic plans for cloud in IT strategy |
| | CR | 1 | Sensitive data regulation requirements |
| | | 2 | Awareness of local regulations on cloud usage |
| Inappropriate Areas (0%) | RE | 1 | Network bandwidth calculation |
| | IN | 1 | Enterprise service bus |
| | | 2 | Awareness of application interoperability standards |
| | SL | 1 | Exit procedures and clauses definition |
| | MP | 1 | Including stakeholders in service readiness assessment |
| | CR | 1 | Existence of cloud ownership policies |

- **University-B Readiness Criteria Analysis**

The Radar Chart in Figure 7-4 illustrates the University-B's scores against each of these RC. The University-B achieved scores for each RCs are further described in the points given below:

- **Excellent Areas:**
  - Security – 79%

**Action required:** *'The area need to be persistent and no improvement is required, that is, the process area is managed quite well and no action needs to be taken before considering the migration process'.*

- **Good Areas:**
  - Reliability – 70%

**Action required**: *'The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration'*

- **Adequate Areas:**
  - Compliance with Regulations – 30%
  - SLA Requirements – 47%
  - Interoperability – 46%
  - Migration Planning – 33%

**Action required:** *'The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration'*

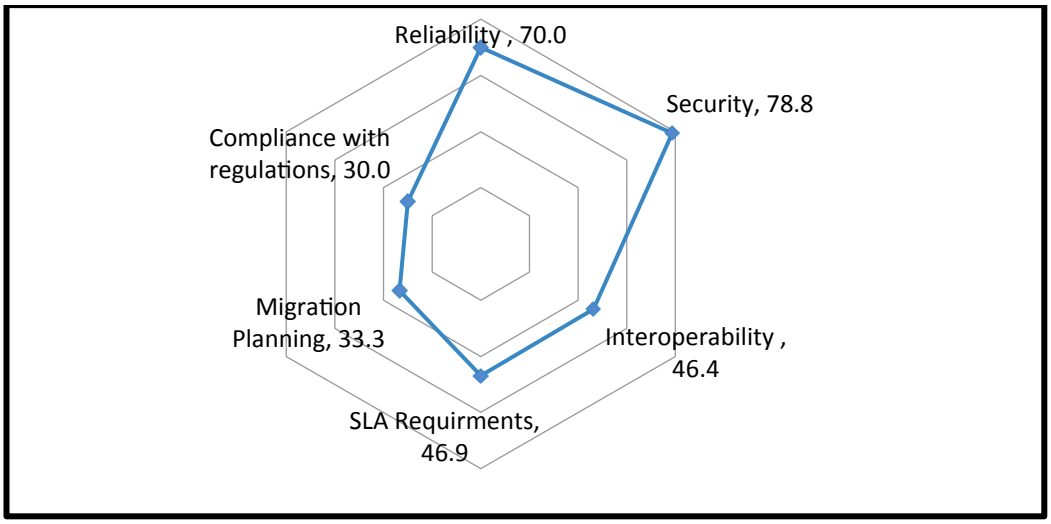


Figure 7-4: Analysis of University-B various RC scores achieved

- **Discussion of University-B results**

As highlighted in the previous bullet points, University-B showed 12 processes in the 'Optimised' (100%) range. These include 'Authentication capability' and 'Documentation of technical support requirements'. The 'Authentication capability' had a 100% (optimised) score, which is further justified by the respondents' comments that the university stakeholders' authentication mechanism is linked directly to their national security number (in Saudi Arabia, each citizen has an identity number). Moreover, 'Documentation of technical support requirements' had a 100% score, as a comment had indicated that the dealing with IT service providers and facing numerous problems earlier on had made them experienced in managing technical support requirements. Similarly, five of the processes were at the 75% (managed) process maturity level. These include 'Provision of recovery techniques', 'Physical security techniques' and 'Existence of cloud RFP document'. For 'Provision of recovery techniques', a comment indicated the presence of an array of passive recovery systems (for server recovery) capable of providing a passive server for each active server automatically to become active in case of a failure. For 'Physical security techniques', a routine physical safety check is performed for the data centre.

Under 'Existence of cloud RFP document' process, the respondents indicated experience in such a document preparation, as they had prepared documents for similar IT projects with Microsoft and other ISPs. Further ahead, 13 processes were categorised at the 'Initial' (25%) process level. 'Compensation and remediation requirements' was among these 13, as the respondent had indicated an absence of any terms for compensation if the service provider did not meet the service level guaranteed in the contract. 'Strategic plans for cloud in IT strategy' was from a comment by a respondent on the absence of qualified IT staff for strategy establishment, although this shortage was addressed by consulting other Saudi universities or IT service providers. Five processes were categorised as a 'Non-existent' (0%) process. One comment on this process, 'Network bandwidth calculation', indicated a complete lack of awareness.

In addition to the abovementioned comments, many suggestions were made. These included provisioning the capability of the cloud provider and the client to manage appropriate bandwidth for the cloud service. Moreover, there was a suggestion to increase numbers of qualified security personnel, especially in database security, to enhance security readiness for the cloud. With regards to the migration planning, a suggestion was to extend the migration to the cloud not only as a user but as a service provider. Under the 'Compliance with regulations' process, a suggestion

was to have a direct formal channel to communicate with Saudi IT governing bodies.

The RC status of various aspects at University-B range between 'Excellent Areas', 'Good Areas' or 'Adequate Areas', as discussed above. For 'Security practices' at the university, the score was in the 'Excellent Area' range at 79%. The lowest scores belonged to 'Compliance with regulation' and 'Migration planning,' at 30% and 33% respectively. Based on the readiness assessment of all the assessment criteria, the overall readiness score percentage for University-B in the Technological Readiness domain was 77% and in Organisational Readiness was 48%. Hence, the overall score for University-B's readiness status is **62.7%,** thereby prompting the following required action:

> *'Solid level of readiness for cloud migration,* **Minor improvements are needed to bring the readiness score to the successful readiness level for cloud migration'**

### 7.1.5 University-C case study findings and discussions

The case study is a Saudi government university with about 41,000 students and employees. The university was established seven years ago and, like the two previous universities, it is considered a start-up university. The university has invited three different cloud providers to provide it with cloud hosting offers. However, it did not consider these offers seriously due to data centre and infrastructure updating. The participants in the case study were IT experts and specialists in the deanship of IT. The participating IT personnel profiles are depicted in Table 7-13. For full details about the results presented to the university, see Appendix I.

Table 7-13: Participants' Profiles

| University-C Case Study Participants Profiles | |
|---|---|
| **Years of Expertise** | **Job Role** |
| **Group-A.C Participants** | |
| **10 years** | Network Security Administrator |
| **6 years** | Storage & Virtualisation Engineer |
| **10 years** | Network Engineer |
| **2 years** | IT software Developer |
| **Group-B.C Participants (Seniors)** | |
| **15 years** | **A:** Senior Head of Programming and web development departments |
| **13 years** | **B:** Vice-Dean of IT deanship - IT System Administrator |

- **University-C AHP Weights for the RCs**

Table 7-14: Aggregated Weights of Group A.C Participants for RCs importance

| **Technological Readiness Criteria** | | | | |
|---|---|---|---|---|
| | Security | Interoperability | Reliability | Weights (%) |
| **Security** | 1 | 7 | 6 | 76.4 |
| **Interoperability** | 1/7 | 1 | 1 | 11.5 |
| **Reliability** | 1/6 | 1 | 1 | 12.1 |
| **Organisational Readiness Criteria** | | | | |
| | SLA Requirements | Migration Plan | Compliance with Regulations | Weights (%) |
| **SLA Requirements** | 1 | 2 | 1 | 24 |
| **Migration Plan** | 1/2 | 1 | 1/3 | 21 |
| **Compliance with Regulations** | 1 | 3 | 1 | 55 |

- **The results of the University-C readiness status**

The readiness score for each RC the university-A scored as resulted from participants' focus group analysis are illustrated in Table 7-15 for the technological RCs and Table 7-16 for organisational RCs.

Table 7-15: University-C Readiness Score Results for the Technological Domain

| RC No | RC Title | PQ No | PQ Title | Readiness Score (%) |
|---|---|---|---|---|
| 1 | **Reliability (RE)** Weighted Readiness Score: **4.025%** | 1 | System workload spike time identification | 75 |
| | | 2 | Up-time for the IT services | 75 |
| | | 3 | Data latency assessment | 0 |
| | | 4 | Network bandwidth | 0 |
| | | 5 | Provision of recovery techniques | 25 |
| 2 | **Security (SE)** Weighted Readiness Score: **41.13%** | 1 | Information security standards adoption | 25 |
| | | 2 | Malicious activities control | 50 |
| | | 3 | Non-repudiation controls | 50 |
| | | 4 | Integrity controls | 25 |
| | | 5 | Access lists | 75 |
| | | 6 | Authentication capability | 75 |
| | | 7 | Security auditing | 50 |
| | | 8 | Documentation of security policies | 25 |
| | | 9 | Privacy controls requirements | 75 |
| | | 10 | Evaluating data centre protection | 100 |
| | | 11 | Security-driven cloud-model selection | 75 |
| | | 12 | Critical IT categorisation | 50 |
| | | 13 | Cloud security risks awareness | 25 |
| 3 | **Interoperability (IN)** Weighted Readiness Score: **4.75%** | 1 | Identifying legacy systems special requirements | 75 |
| | | 2 | Scaling out application architecture | 75 |
| | | 3 | Evaluation SOA design in applications | 50 |
| | | 4 | Enterprise service bus | 25 |
| | | 5 | Awareness of application interoperability standards | 0 |
| | | 6 | Application interoperability status identification | 25 |
| | | 7 | Data portability evaluation | 25 |
| **Total Technological RCs obtained readiness score (%)** | | | | 49.9% |

Table 7-16: University-C Readiness Score Results for the Technological Domain

| RC No | RC Title | PQ No | PQ Title | Readiness Score (%) |
|---|---|---|---|---|
| 1 | **SLA-Requirements (SL)** Weighted Readiness Score: **8.25%** | 1 | Exit procedures and clauses definition | 0 |
| | | 2 | Existence of cloud RFP document | 25 |
| | | 3 | Cost requirements for migrated services | 25 |
| | | 4 | Document of compensation and remedy | 25 |
| | | 5 | Service customisation requirements | 50 |
| | | 6 | Documentation and technical support | 75 |
| | | 7 | Customisation of security requirements | 50 |
| | | 8 | Identifying the service level required for the migrated services | 25 |
| 2 | **Migration Planning (MP)** Weighted Readiness Score: **7%** | 1 | Top management support for the cloud migration | 50 |
| | | 2 | Migrated services impact assessment | 75 |
| | | 3 | Identifying IT skills required | 0 |
| | | 4 | Building cloud knowledgebase | 25 |
| | | 5 | Including stakeholders in service readiness assessment | 25 |
| | | 6 | Strategic plans for cloud in IT strategy | 25 |
| 3 | **Compliance with regulations (CR)** Weighted Readiness Score: **13.75%** | 1 | Sensitive data regulation requirements | 25 |
| | | 2 | Alignment with government legal and regulatory requirements | 50 |
| | | 3 | Identifying providers licensed by the government | 25 |
| | | 4 | Existence of cloud ownership policies | 0 |
| | | 5 | Awareness of local regulations on cloud usage | 25 |
| **Total Organisational RCs obtained readiness score (%)** | | | | 29% |

- **University-C PQs Status Analysis**

The process readiness status of each RC is on the basis of its status level are provided in Table 7-17:

Table 7-17: University-C PQs Status Analysis

| RC status | RC abbreviation | PQ No | PQ title |
|---|---|---|---|
| Excellent Areas (100%) | RE | 1 | Evaluating data centre protection |
| Good Areas (75%) | RE | 1 | Up-time for the IT services |
| | | 2 | Up-time for the IT services |
| | SE | 1 | Access lists |
| | | 2 | Access lists |
| | | 3 | Authentication capability |
| | | 4 | Security-driven cloud-model selection |
| | IN | 1 | Scaling out application architecture |
| | | 2 | Identifying legacy systems special requirements |
| | SL | 1 | Documentation and technical support |
| | MP | 1 | Migrated services impact assessment |
| Adequate Areas (50%) | SE | 1 | Malicious activities controls |
| | | 2 | Non-repudiation controls |
| | | 3 | Security auditing |
| | | 4 | Critical IT categorisation |
| | IN | 1 | Evaluation SOA design in applications |
| | SL | 1 | Service customisation requirements |
| | | 2 | Customisation of security requirements |
| | CR | 1 | Alignment with government legal and regulatory requirements |
| Marginal Areas (25%) | RE | 1 | Provision of recovery techniques |
| | SE | 1 | Information security standards adoption |
| | | 2 | Integrity controls |
| | | 3 | Documentation of security policies |
| | | 4 | Cloud security risks awareness |
| | IN | 1 | Enterprise service bus |
| | | 2 | Application interoperability status identification |
| | | 3 | Data portability evaluation |
| | SL | 1 | Cost requirements for migrated services |
| | | 2 | Document of compensation and remedy |
| | | 3 | Identifying the service level required for the migrated services |
| | | 4 | Existence of cloud RFP document |
| | MP | 1 | Building cloud knowledgebase |
| | | 2 | Including stakeholders in service readiness assessment |
| | | 3 | Strategic plans for cloud in IT strategy |
| | CR | 1 | Sensitive data regulation requirements |
| | | 2 | Identifying providers licensed by the government |
| | | 3 | Awareness of local regulations on cloud usage |
| Inappropriate Areas (0%) | RE | 1 | Data latency assessment |
| | | 2 | Network bandwidth |
| | IN | 1 | Awareness of application interoperability standards |
| | SL | 1 | Exit procedures and clauses definition |
| | MP | 1 | Identifying IT skills required |
| | CR | 1 | Existence of cloud ownership policies |

- **University-C Readiness Criteria Analysis**

The Radar Chart in Figure 7-5 illustrates the University-C's scores against each of these RCs. The University-B achieved scores for the RCs that are further described in the points given below:

- **Good Areas:**
  - Security – 54%

**Action required:** *"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

- **Adequate Areas:**
  - SLA Requirements – 34%
  - Interoperability – 39%
  - Reliability – 35%
  - Migration Planning – 33%

**Action required:** *'The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration'*

- **Inappropriate Areas:**
  - Compliance with Regulations – 20%

**Action required:** *'There are major issues and weakness areas and serious consideration is required to before migrating to the cloud'*

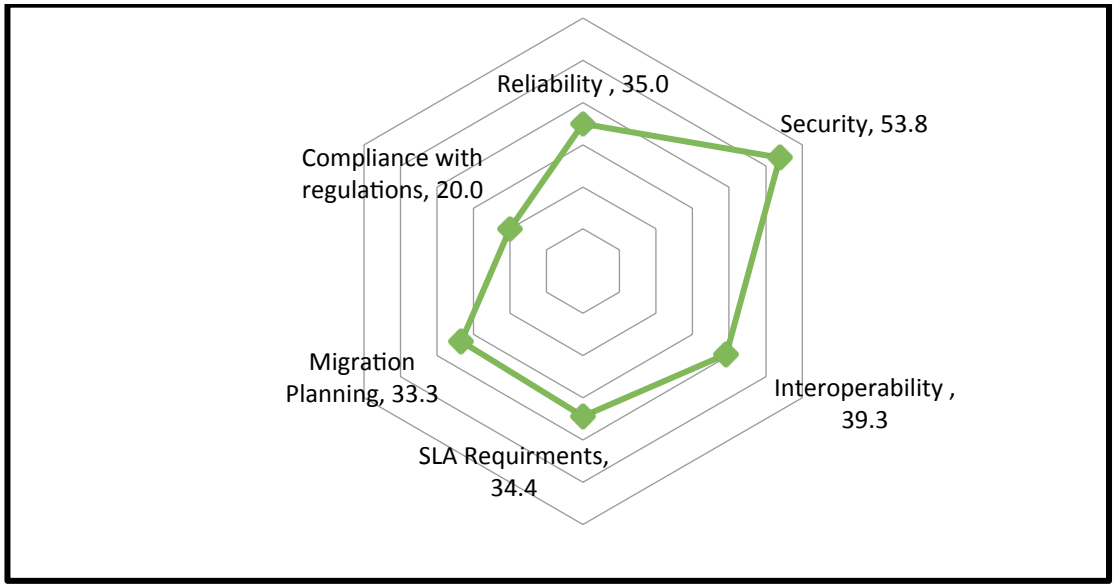


Figure 7-5: Analysis of University-C various RC scores achieved

- Discussion of University-C results

As highlighted in the above bullet points, University-C had a single process in the 'Optimised' (100%) range. This is 'Physical protection evaluation', which is further justified by the respondents' comments that, with regards to the in-house data centre, they have a routine inspection and requirement to keep the data centre safe. However, they are only internal and, for the cloud provider's data centre, they do not yet have a formal process.

Similarly, 10 of the processes were at the 75% (managed) process maturity level. These include 'Identifying high up-time', 'Access lists' and 'Defining impact metrics'. For 'Identifying high up-time', it was commented that the university services were up 24/7 and that any interruption was fixed by the IT team immediately.

With regards to 'Access lists', efforts were underway to improve them while adhering to best practice. For the 'defining impact metrics' process, the respondents indicated a dedicated department to monitor and rate the IT service providers and set up regular meetings with the provider to fix any issues, while avoiding companies with lower performances. Further ahead, nine processes were categorised at the 'defined' (50%) process level. 'Malicious activities detection' was among these, where the respondent stated the availability of firewalls and special traffic filtering techniques for malware detection. Seventeen processes were categorised as an 'initial' (25%) process.

Under the 'Request for proposal document' process, one comment stated its presence for IT projects, but not for the cloud. Another comment was on 'gathering knowledge about the cloud', where the university is still investigating cloud offers and services while reviewing expert comments.

In addition to the abovementioned comments, many suggestions were made. These included the introduction of a logging feature capability for all security devices such as system and server/IP logs, with consideration of user level security such as the Cisco Identity Service Engine. Moreover, with regards to suggestions to ensure system interoperability, the respondent suggested encoding tools to ease migrating the data from different platforms.

Most RCs' status in University-C ranged between 'Good Areas', 'Adequate Areas' and 'Inappropriate Areas' as discussed above. For 'Security practices' at the university, the score was in the 'Good Area' range at 54%. The lowest scores belonged to 'Compliance with Regulation', at 20%. Based on the readiness assessment of all the assessment criteria, the overall readiness score percentage for University-C in the Technological Readiness domain was 49.91% and in

Organisational Readiness was 29%. Hence, the overall score for University-C readiness status is 39.45%, thereby giving the following, required action:

> **'*Average level of readiness for cloud migration,* considerable improvements are needed for successful cloud migration project'**

## 7.2 Practicality of the CMRA instrument

The next phase in the case studies was to understand the practicality and usefulness of the CMRA instrument. This was achieved by conducting an evaluation study for both the participants who applied the tool to assess their university readiness and the senior managers who were introduced directly to the results without using the tool. First, 12 participants from various IT specialities, working in the three case studies universities, contributed in a focus group and were asked to evaluate the practicality of CMRA instrument through an evaluation questionnaire (see Appendix J).

In the questionnaire, the ECM constructs, perceived usefulness, user satisfaction and the perception of congruence between expectation of use and its actual performance were adapted to evaluate the CMRA instrument. Subsequently, five senior members of IT departments in the three universities were invited to review the results generated from the readiness assessment focus group.

Before being given the report, they were interviewed via semi-structured interviews to query the existing procedures of preparation to migrate to the cloud and their perception of the readiness of their university. During the presentation of the report findings and results, each of these seniors was given the report and at the end of each readiness criteria result they were asked: 'Do you believe the scores presented in this RC section reflect your true readiness level or capability to undertake the cloud migration in your university?'.

At the end of the interview sessions, they were asked: ***'To what extent do you believe this instrument is useful in measuring weaknesses as well as strengths of the cloud migration processes' readiness in the Saudi universities' context?'*** Thus, their perception was queried after introducing the study findings to them to assess the overall change in their opinion and discuss the usefulness of the proposed CMRA instrument.

### 7.2.1 Reliability of the evaluation survey items

The questionnaire was distributed and returned by all 12 members, representing 100% of the population. There were no issues with regards to the questions. Cronbach's alpha test was used to ascertain the reliability of the survey question items for each construct and to examine the internal consistency of the measuring items that belong to the same construct (Cronbach, 1951).

Table 7-18: Cronbach's alpha value for each construct

| Construct Name | Total Items | Evaluation Statements | Alpha |
|---|---|---|---|
| **Perceived Usefulness** | 4 | Using this tool helps assess the readiness status of my organisation for cloud migration. | 0.818 |
| | | Using this tool increase my awareness about the areas need to be assessed before the migration to the cloud. | |
| | | Using this tool enhances my effectiveness in managing and assessing the cloud migration readiness status of our organisation. | |
| | | Overall, this tool is useful in assessing and assuring the readiness level of our University for the cloud migration. | |
| **Satisfaction** | 3 | I am satisfied about our organization readiness results after using the tool. | 0.729 |
| | | I am content with the experience of using the tool | |
| | | Overall, how would you rate your overall satisfaction about the tool? | |
| **Confirmation** | 3 | My experience with using the tool was better than what I expected | 0.71 |
| | | The service level provided by this tool was better than what I expected | |
| | | Overall, most of my expectations from using this tool were confirmed. | |

Table 7-18 shows that Cronbach's alpha values for each of the constructs range between 0.71 to 0.818, which exceeds the threshold of 0.7, indicating that the measures of each construct are reliable. The evaluation questionnaire aimed to assess the practicality of CMRA instrument in assessing Saudi university readiness for cloud migration from university IT personnel's perspective.

### 7.2.2 Evaluation Questionnaire Data Analysis

All participants who used the CMRA instrument to assess the readiness of their organisation were also involved in this questionnaire. The data was analysed with the SPSS software package to evaluate the perception of IT personnel towards the CMRA instrument. Table 7-19 depicts the results of the one-sample t-test conducted to decide whether the mean rating for each question was substantially different from the rating of 3. Here, a rating of 3 indicates 'neither agree nor disagree' on the five-point Likert scale used for this study.

Table 7-19: One sample t-test statistics for the evaluation questionnaire results

| Evaluation Variables | N | Sig. (2-tailed) | Mean | Std. Deviation |
|---|---|---|---|---|
| **Q1 - Usefulness** | 12 | < 0.0001 | 4.08 | 0.669 |
| **Q2 - Usefulness** | 12 | < 0.0001 | 4.58 | 0.515 |
| **Q3 - Usefulness** | 12 | < 0.0001 | 4.17 | 0.718 |
| **Q4 - Usefulness** | 12 | 0.002 | 4.00 | 0.853 |
| **Q1 - Satisfaction** | 12 | 0.043 | 3.75 | 1.138 |
| **Q2 - Satisfaction** | 12 | 0.002 | 4.00 | 0.853 |
| **Q3 - Satisfaction** | 12 | < 0.0001 | 4.08 | 0.669 |
| **Q1 - Confirmation** | 12 | 0.002 | 4.08 | 0.900 |
| **Q2 - Confirmation** | 12 | < 0.0001 | 4.25 | 0.754 |
| **Q3 - Confirmation** | 12 | < 0.0001 | 4.00 | 0.739 |

The analysis in Table 7-19 indicates that participants agreed on the practicality and usefulness of the proposed instrument, as the mean value of each evaluation construct was greater than the test value of 3. Moreover, all the evaluation items in the questionnaire were deemed significant, as the p values for all the constructs' items were less than 0.05, confirming that participants felt significantly positive towards the practicality and usefulness of the CMRA instrument.

It is demonstrated in Figure 7-6 that the participants perceived that the CMRA instrument was useful in measuring their readiness status. It also demonstrates satisfaction with the CMRA instrument results. Finally, their expectations of the CMRA instrument were also met as the confirmation construct scored 4.11 out of 5.

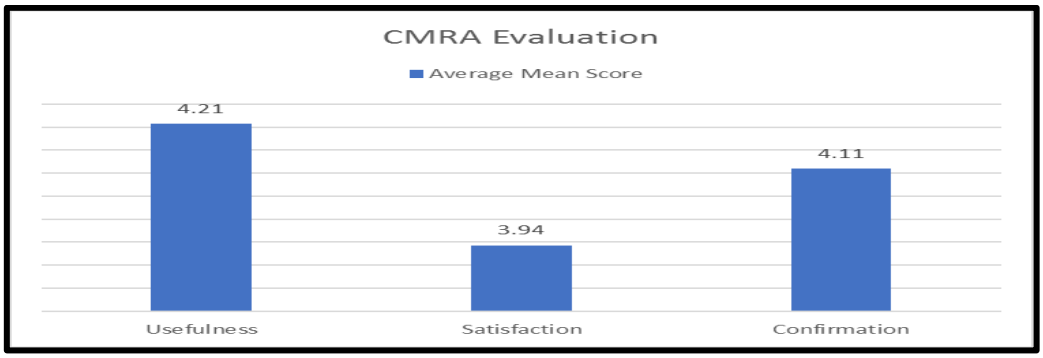


Figure 7-6: Mean of each scale of CMRA evaluation tool

Figure 7-7 shows various perception levels of the three universities towards the CMRA instrument continuance intention. Universities-B and -C perceived a similar level of usefulness (4.56 and 4.3 respectively) for the CMRA instrument whereas University A had a relatively lower (3.5) usefulness perception. The perceived usefulness score of University-A was also the lowest in all constructs. Moreover, construct scores for Universities B and C were always within 4 and 5 whereas University-A scores always lagged and stayed between 3.5 and 3.9.

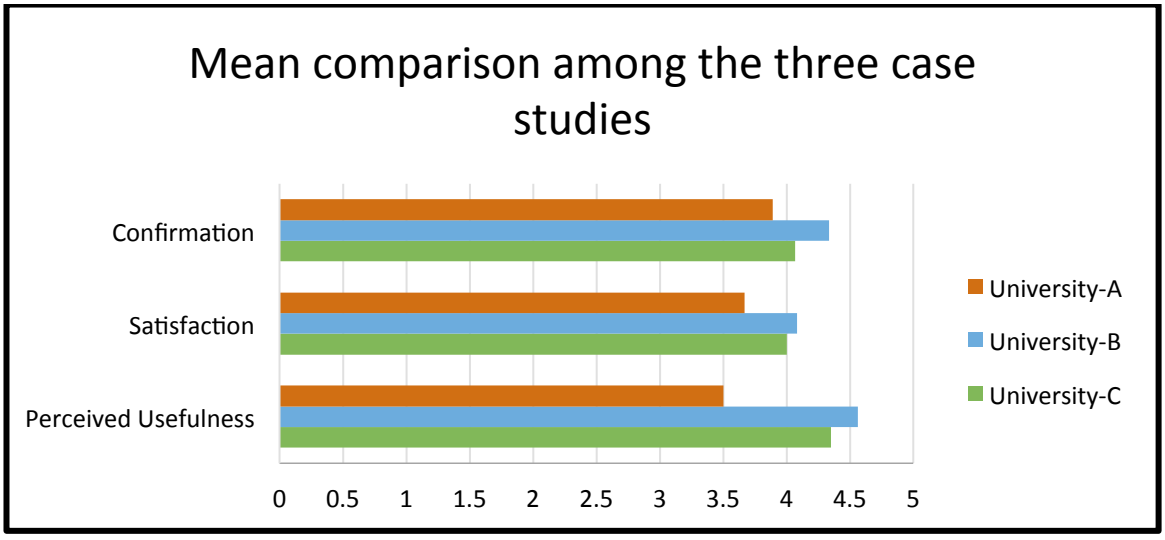


Figure 7-7: Construct evaluation mean comparison of the three Universities

- **Perceived Usefulness:**

As evident from Figure 7-8, the items belonging to the perceived usefulness construct indicated that all the universities' IT personnel were convinced of the usefulness of the CMRA instrument. They accepted that the instrument would increase their awareness, assure the readiness level, enhance their effectiveness to manage and assess the readiness status of their university. Overall, the IT team's perceived the usefulness of CMRA instrument for assessing and assuring the readiness of their university for cloud migration.

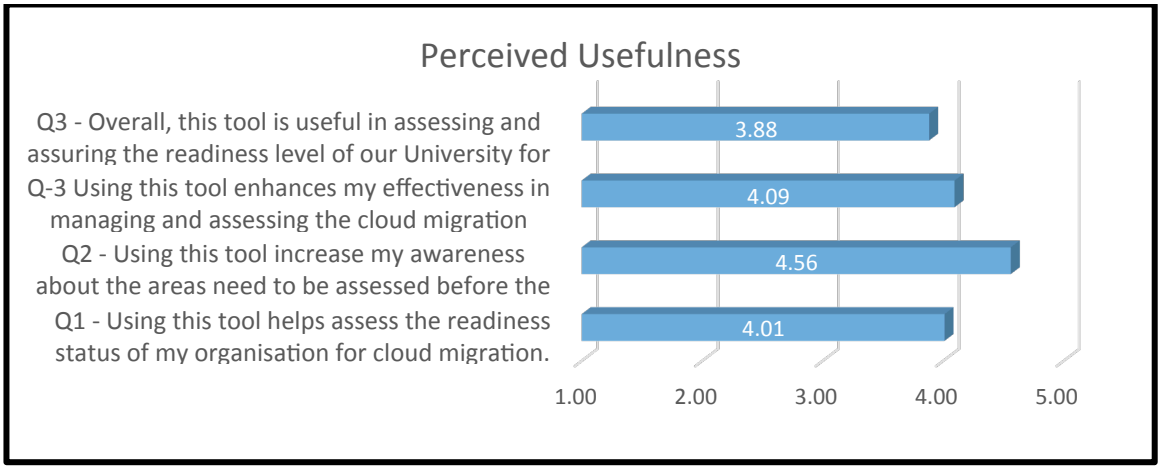


Figure 7-8: Perceived Usefulness construct results

- **Satisfaction:**

Using the CMRA instrument to assess the university's cloud migration readiness status was perceived to be satisfactory by the three IT teams in the conducted case studies, as shown in Figure 7-9. There was an overall contentment with regards to the tool usage experience. Moreover, the IT team was satisfied with the readiness status generated by the tool. There was an overall satisfaction with the tool.

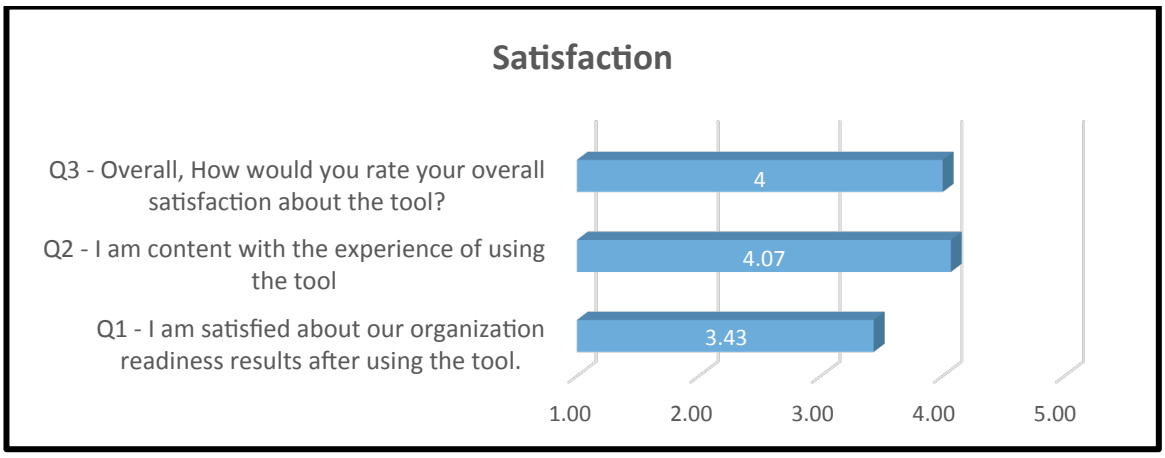


Figure 7-9: Satisfaction construct results

- **Confirmation:**

The scale shown in Figure 7-10 presents users' perception of the congruence between expectation of CMRA instrument used and its actual performance. It shows that the users confirmed that most of their expectations with the tool were confirmed. The result confirms that the users' experience and the service level of CMRA were better than expected, scoring 4.1 and 4.24 respectively.

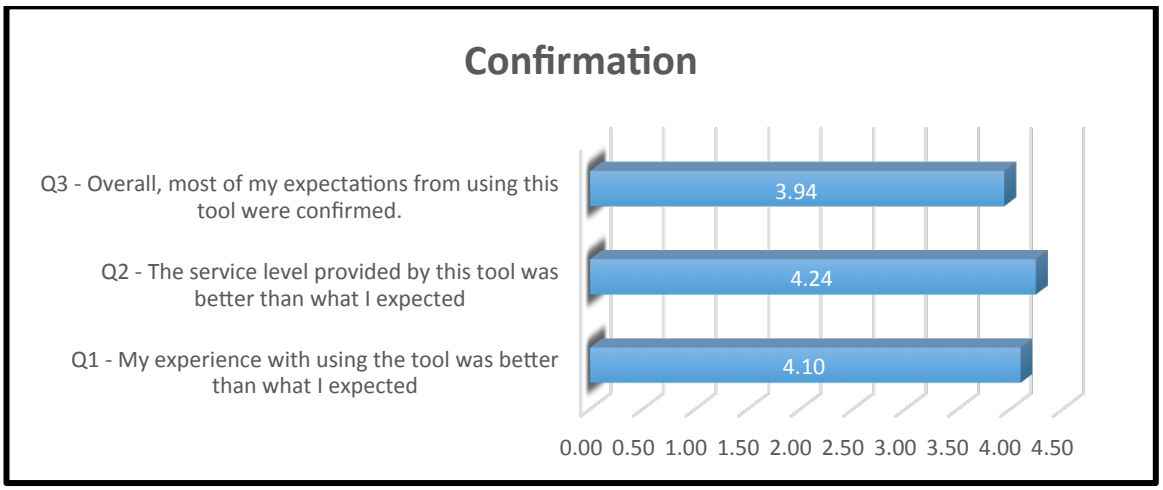


Figure 7-10: Confirmation construct results

### 7.2.3 Seniors' feedback of the CMRA instrument practicality

As discussed in section 7.2, five senior members (Group-B participants) in the three universities provided feedback on the practicality of the CMRA instrument by answering: '***Is the CMRA instrument appropriate for measuring the readiness status of your university for cloud migration?'*** Their feedback was sought in two steps. First they were interviewed and asked about the processes or procedures they used to plan for cloud migration, moreover how confident they are about their readiness status. Then they were presented with their respective university's readiness report. In the report, they were asked to reflect on their individual perception of whether the results presented in each readiness criteria section reflected the actual readiness status or not.

Seniors' feedback is shown in Table 7-20. A comparison of the feedback from the three case studies is presented as individual feedback for each question from all case study universities. With regards to rating score system for the effectiveness of the CMRA instrument, the following system has been developed: Strongly Agree (SA) is 5, Agree (A) is 4, Neutral (N) is 3, Disagree (D) is 2 and Strongly Disagree (SD) is 1.

Table 7-20: Seniors' Feedback Summary on Case Studies

| Feedback question | University-A | University-B | University-C | Feedback Result |
|---|---|---|---|---|
| Q1: Reliability (RE) | A | A | A | 3.83 |
| Q2: Security (SE) | SA | A | D | 3.33 |
| Q3: Interoperability (IN) | A | A | SA | 4.33 |
| Q4: SLA Requirement (SL) | SA | SA | A | 4.33 |
| Q5: Migration Plan (MP) | A | SA | SA | 4.50 |
| Q6: Compliance with Regulations (CR) | SA | SA | SA | 4.67 |
| Q7: Overall Readiness Level | A | SA | SA | 4.50 |
| Q8: CMRA Usefulness | SA | SA | A | 4.50 |

As illustrated in the table, most of the seniors were in either strong agreement or agreement, apart from on Q2, where concerns were raised about the security aspect of the relevant organisation by University-C. However, this did not affect the overall results as all the questions scored 4 or above. Hence, all the CMRA instrument's readiness criteria and processes reflect the actual status of their readiness for cloud migration. There was a consensus agreement on the CMRA's usefulness in measuring the readiness for cloud migration from all seniors, with a high score of 4.5.

With regards to the interview questions, the discussion focused on obtaining constructive feedback on the practicality of the CMRA instrument. The questions that were asked covered subjects such as:

- **Q1** - Current processes/procedures followed to prepare for cloud migration
- **Q2** - Their perception about the readiness status of their university for cloud migration in percentage and their confidence before showing them the case study results' report
- **Q3** - Their perception about the readiness status of their university for cloud migration in percentage and their confidence after showing them the case study results' report
- **Q4** - The practicality and effectiveness of the CMRA instrument

### ❖ Seniors' responses to Q1:

With regards to the current processes that the three universities followed to prepare for cloud migration, there was a diverse response. University-A completely denied the presence of any formal procedures followed to prepare it for cloud migration as per the following quotation from **University A - Senior A:**

> *'Internally we do not have any sort of procedures to measure our readiness for cloud services. However, one local company came to us and provided us with an offer to migrate our services to the cloud. We showed them our infrastructure and they guided us through the process*

*of the migration. Prior to their offer we did not have any background about how to manage migration to the cloud. We do not have any documented plans to go to the cloud'*

University B did follows a set of procedures for any IT projects, as noted by **University-B-Senior-B:**

*'We start by defining the need of the university for any certain technology. Secondly, we prepare the specifications and the requirements for the project, which include all the technical and the managerial requirements related to the project. Afterwards, we prepare the project documents and the study of the offers provided by the companies'*

Moreover, in the scope of cloud-computing migration projects, the input from **University-B-Senior-A** was as follows:

*'In term of the cloud project, our University has been provided with a study from a company that provide cloud services and it offered us with beta version for the project. The results of their study were stunning as they concluded in their report that the university is ready to go to the cloud immediately and has fulfilled most of the requirements based on their judgment. They also offered a trail project for the cloud it might be executed very soon'*

Finally, University C showed a more forward-looking approach to cloud migration by stating its willingness to update its servers and infrastructure, although the actual plan to migrate to the cloud was still not in place, as evident from the input quoted from **University-C-Senior-A:**

*'We also have not received any offer from any cloud provider either international provider or local provider like the telecommunication companies. We are thinking as next stage to consult IT experts regarding the cloud migration project'*

❖ **Seniors' responses to Q2:**

The second question is focused on the perception about the readiness of the seniors' university for cloud migration, which was collected as percentage values and included their confidence level before they were presented with the case study results. University-A's response to the abovementioned question showed part readiness as shown in the input from **University-A-Senior-A:**

*'I can say that we are about 30% ready to go to the cloud due to our recent establishment as a start-up university that was only established 2 years ago.'*

On a scale of 5, they were asked to rate their level of confidence on their university's readiness for cloud migration. The response from all the seniors was 2 out of 5. By contrast, University-B's response showed a higher confidence on their university's readiness as input by **University-B-Senior-A:**

> *'I believe we are up to 90% ready to go to the cloud paradigm based on our infrastructure and IT hardware.'*

Again, on a scale of 1 to 5, they were asked to rate their level of confidence in their university's readiness for cloud migration. The response from all the seniors was averaged at 4 out of 5. University-C participants also showed a confidence level that put them at an initial level, as is evident in the following comment by **University-C-Senior-A:**

> *'As we are still at the beginning of the project I think we are 40% and ready to migrate our ICT services to the cloud.'*

Like the previous two cases, on a scale of 5, they were asked to rate their level of confidence on their university's readiness for cloud migration. The response from all the seniors was averaged at 3 out of 5.

❖ **Seniors' responses to Q3:**

The third question is focused on perceptions about the readiness of the seniors' university for cloud migration, which was collected as percentage values and included their confidence level after they were presented with the case study results.

In the case of University-A, as it was already a start-up university, the confidence level remained at 2 out of 5 with **University-A-Senior-B** stating:

> *'I believe the results generated from the tool has reflected our actual status and show and provide us with the reasons why we are still not ready.'*

In contrast to the case of University-A, the confidence level of University-B dropped from 4 to 3 out of 5 after showing the seniors the case study results. This was evident from the input provided by University-B-Senior-B as follows:

> *'After I have been provided with the result of this study based on the outcome of the two domains: the technological and the organisational sections, I believe 90% is too much and I can place our university readiness between 70% to 75%'*

Like University-B, **University-C-Senior-A** also downgraded his confidence level about the university's readiness status from 3 to 2 stating:

> *'After I am shown the results generated by the instrument, I believe our readiness status is lower than what I was expecting'*

### ❖ Seniors' responses to Q4

The fourth question queried the seniors about their overall feedback about the CMRA instrument.

According to **University-A-Senior-B,** the tool disclosed important issues that they were unaware of about their readiness to migrate to the cloud. This is reflected in his comment below:

> *'The tool has provided us with issues related with the readiness of our university to migrate to the cloud which we did not aware about them before...'*

Moreover, the seniors also found CMRA to be a useful instrument that provided them with the opportunity to reflect on their actual readiness, and which could then be used to identify strengths and weaknesses in their overall cloud migration setup. This is evident in University-A-Senior-A's comment:

> *'I think it is a very useful tool and reflects our actual status and it can be used as reference to guide us through the weakness and strength spots we have before executing the cloud migration project...'*

Similar feedbacks were obtained from the **University-B-Senior-B,** who stated that:

> *'I really found it a very detailed tool, which gave us a very clear picture and clarifications about processes and areas we did not know or considered them ... It identified to us the weakness points that we thought we are good at it...'*

There was a suggestion to improve the CMRA instrument on the scoring mechanism from **University-B-Senior-B** as follows:

> *'... However, the suggestions for the scores need to be associated with more detailed recommendations.'*

**University-C-Senior-A** gave similar feedback as he stated that the CMRA instrument can provide critical hints and suggestions about the critical important processes that need to be considered before migrating to the cloud. The comment stated:

*'I overall recommend this tool to any organisation willing to migrate to the cloud and I rate it 4 out of 5 in terms of the usefulness of the results and the accuracy of the outcome against the actual status of the organisation.'*

## 7.3 Chapter summary

This chapter discussed the case studies and the experimental results, which were then used to demonstrate the SFCM2 and its CMRA instrument. The CMRA instrument objective was to measure the preparedness of universities willing to move their traditional ICT to cloud-based services. The final version of the CMRA instrument provided the overall measuring processes for each of the readiness criteria.

The instrument also used an aggregation formula to integrate the final readiness score. First, the participants were asked questions on their perceptions of various current cloud migration issues. Then, three real case studies were conducted in the IT deanships of three Saudi universities to evaluate the usefulness and practicality of the CMRA instrument. In total, 17 IT experts were involved during the case studies in assessing their university's readiness for cloud migration by using CMRA and evaluating the usefulness of CMRA, and whether the results generated by the instrument reflect their actual readiness status.

Subsequently, the IT experts were asked to evaluate their experience of the CMRA instrument through a self-administered questionnaire using ECM constructs. The questionnaire measured three constructs: 'perceived usefulness'; 'user satisfaction'; and 'perception of congruence between expectation of the use and its actual performance'. Additionally, the cloud readiness report results were discussed with five senior managers to examine their perceptions of the proposed CMRA instrument.

The findings of these case studies are that the SFCM2 framework and its CMRA instrument have a good level of practicality, as the assessment results satisfied both the senior IT experts and the IT specialists in the IT deanships. The findings of the questionnaire confirm the practicality of the CMRA instrument.

# Chapter 8

# Conclusions and Future Work

This chapter provides a final review of the research conducted in this thesis. The main contributions are presented in section 8.2. The last section of this chapter covers the future directions of this research.

## 8.1 Conclusions

The core aim of this research was to investigate and develop a cloud migration framework while exploring various success factors that could potentially increase the likelihood of success in a cloud migration project. As the context of this research focused mainly on Saudi Arabian higher education institutions, it revealed factors that were significantly relevant to various technological and organisational aspects. Further exploration of these aspects leads to the identification of success factors pertaining to measuring Saudi universities' preparedness to migrate to the cloud. In order to achieve the main aim of this research, a set of objectives were proposed in section 1.3 and these were achieved during the research. Table 8-1 illustrates the methods of investigation used to attain these objectives.

The framework development started with an in-depth literature review to extract and synthesise the CSFs related to the research context. Subsequently, the CSFs identified by reviewing the secondary research were proposed in an initial SFCM1 framework. They were confirmed using a mixed-method triangulation research design (13 interviews and 41 questionnaire responses) conducted with IT experts in various Saudi universities. The confirmed framework encompasses two domains: technological and organisational. The technological domain's CSFs are security, reliability and interoperability, while the organisational are SLA requirements, migration plan and compliance with regulations.

As the framework was initially in a theoretical form, in order to empirically validate it, it had to be apply in real-world cases. Therefore, based on the confirmed framework (SFCM2), CMRA instrument was developed to measure the readiness status of the Saudi universities for cloud migration.

Table 8-1: Summary of the Research Methods and the Objectives

| Objective | Method of Investigation | Chapter |
|---|---|---|
| • **To review the literature on cloud migration approaches and frameworks critically while investigating the global context of cloud migration leading to the case of Saudi universities** | Desk Research which involves a synthesis and collation of challenges and CSFs pertain to cloud migration project in general and IT project failure and success factors pertain to the context of Higher Education in Saudi Arabia. | **2 & 3** |
| • **To investigate challenges, issues and priorities of cloud migration and hence derive a set of "critical success factors (CSFs)" within the context of Saudi Arabian universities** | Desk research to understand IT project failure and success factors within the Saudi Higher education context.<br>Experts' interviews with IT project managers and Cloud experts working in different Saudi universities. | **2 & 5** |
| • **To develop and confirm a framework to identify key enablers to guide Saudi universities to succeed in their cloud migration project** | A confirmatory Study was conducted to confirm the identified CSFs resultant from the literature reviewed for successful cloud migration project in Saudi Universities.<br>This involves an exploratory methodological triangulation design where Interviews and questionnaire data collection were the means to collect the data. | **2 & 3 & 5** |
| • **To develop, evaluate and validate an instrument to measure the readiness of any Saudi Arabian academic institution's ability to migrate to the cloud** | Desk Research to identify the measuring processes for each readiness criteria (CSF) in SFCM2 framework and develop the CMRA instruments using various techniques AHP, GQM and PAM.<br>Content Validation was conducted prior and during applying the CMRA instrument in the three case studies conducted.<br>An evaluation of CMRA instrument's usefulness and practicality was conducted through an evaluation questionnaire and Interview with IT personnel. | **6 & 7** |

The development of the instrument involved adopting various techniques from the literature to shape them for the proposals of this research. These include GQM, chosen to assist in breaking down the CSFs into goals and derive a set of measurements to each goal, and propose the appropriate scales or metrics for each measuring item. The scale levels adopted in CMRA were based on the PAM model for assessing the IT processes' maturity levels. The AHP technique was used to understand the relative weight (importance) of each of the readiness assessment criteria in the CMRA, based on the viewpoint of the IT experts in each case study.

Subsequently, the developed instrument was validated and evaluated through case studies in three Saudi universities. The main aim of these case studies was to assess the practicality and usefulness of the CMRA instrument. The assessment process included focus group interviews, evaluation questionnaires, IT seniors' feedback and interviews.

## 8.2 Thesis contributions

The thesis presented several contributions to knowledge. First, a CSF framework was developed via an in-depth literature review applicable to the context of cloud migration in Saudi Arabian universities. Second, the CSFs identified in the previous step were confirmed in this thesis via an empirical triangulation study, as discussed in detail in Chapter 5. Third, the confirmed framework was used to develop a measurement instrument (CMRA), based on different approaches and the models AHP, PAM and GQM. The developed CMRA instrument was validated and evaluated through three case studies to assess the readiness of Saudi universities for cloud migration and validate the instrument's practicality and usefulness.

The accumulated contribution of this thesis' outcomes can be used in future research on cloud-computing migration in other sectors in the Gulf region, such as health and government agencies. The results in this thesis will also contribute to the literature on cloud computing through empirical evidence from the study results, and give the potential success rate of a cloud-computing migration project to help the decision-making on whether to migrate or not. The results will also provide IT practitioners and cloud services providers with valuable empirical data that can be used in hiring for and advertising cloud-computing services.

### 8.2.1 Development and confirmation of CSFs framework

To answer the first research question, **'What is the appropriate cloud migration success factors framework for Saudi universities?'**; it was imperative that the challenges encountered in a migration process were first understood, hence, to gain a better understanding, an in-depth literature review of challenges hindering the cloud migration process over a global higher education setup was conducted. Having completed the literature review, semi-structured interviews with 13 IT experts were held to confirm the identified challenges. These steps aimed to answer the following sub-question:

**RQ1.1:** What are the challenges of migrating university's ICT to cloud paradigm?

As a result of the review and the interviews in the confirmatory study, a number of challenges were noted:

- Control, data and service availability issues
- Security protocol application
- Legal policy constraints and compliance
- Vendor lock-in, loss of service, SLA, latency, and performance
- Cross-platform interoperability
- Users acceptance and awareness of new cloud-driven paradigm

Similarly, regarding the identification of CSFs, a literature review was conducted first to identify global and cultural potential CSFs not only on cloud migration projects but in various IT projects, such as ERPs and WBL, in the Saudi higher education context. Subsequently, the identified CSFs were confirmed using semi-structured interviews and a structured online questionnaire. This step aimed to answer the following sub-research question:

**RQ1.2** What are critical success factors for cloud migration in Saudi Arabian universities?

The result of these two steps led to six CSFs as illustrated in
Figure 5-3 and discussed in section 5.4.

### 8.2.2 Development and evaluation of CMRA

To answer the second research question, 'RQ2: Based on the confirmed framework, what is the appropriate instrument to measure the readiness status of Saudi Arabian universities for cloud migration?', the first step was to extract and identify readiness criteria and measuring items for cloud migration by conducting further secondary research. The CMRA was developed using various techniques, such GQM, AHP and PAM, as discussed in Chapter 6. This step aimed to answer the following sub-research question:

**RQ2.1:** What are the readiness assessment criteria and their measuring items for cloud migration?

Once the instrument was developed, it was employed to assess the readiness of Saudi universities for cloud migration. Part of the assessment process was to understand the importance of the CMRA's readiness criteria priorities, based on each university's needs and requirements. Therefore, this step has addressed the following sub-question:

**RQ2.2:** Based on the Saudi university requirements, what is the importance/priority of each readiness criterion in the proposed instrument?

Lastly, once the universities participants had assessed their readiness status using the CMRA, the instrument outcome was evaluated and validated for its practicality and usefulness by 12 IT experts and five IT seniors. These steps answered the final sub research question.

**RQ2.3:** How good is the functionality and practicality of CMRA instrument?

## 8.3 Research scope and limitations

The main aim of this research is to develop and then validate a framework that includes the critical factors for successful migration of the Saudi universities IT services to the cloud. The research context in this thesis is the public universities in Saudi Arabia. In order to use the framework in real world settings, the SFCM2 was extended to the research instrument (CMRA) to measure the readiness of Saudi universities for cloud migration project. Therefore, the CMRA research instrument provides an indication of the success of the readiness (preparedness) of Saudi universities, not how can they step by step migrate their legacy systems and application to the cloud. Also, The volunteered Participants involved in the final three evaluation case studies to validate CMRA instrument were from only three different Saudi public universities; this means that the Saudi private universities' context are still not covered in this research. The constraints imposed by the sample of the case studies in this research are derived from the fact that, only three universities have declared their decision to migrate to the cloud within one year during the confirmatory study for SFCM2 in chapter 5. This constrains the research to collect the data from them, since the object of the study is to measure the capabilities or the processes the universities have/follow to migrate to the cloud. Other reason for that limitation is the slow cloud adoption rate in Saudi Arabian universities, which limited the pool of the cases and the respondents.

The research has some limitations and restrictions that need to be highlighted. First to mention is that the CSFs are cyclical in comparison to other measures such as the key performance indicators (KPIs), which are mostly measured either timely wise or repeatedly over certain times. Besides, many of the CSFs in SFCM2 are qualitative factors, which can be challenging to gauge the exact values for these factors. For instance, it can be difficult to calculate how well is the establishment of the strategic plans and objectives of cloud computing within the IT strategy in certain university as this association impact on a university's operating success can be difficult to quantify.

Despite of the limitation of CSFs as measures, the CSFs are critical to both achieving and measuring organizations' goals, and keeping track of the performance progress organization wise, since they provide a direct correlation to an organization's current and future success (Leidecker and Bruno, 1984). Therefore, although CSFs may have some limitations as measurements tool, they are most appropriate in this research as the main aim is to measure the "success" of the readiness to migrate to the cloud not how to conduct the migration process itself or the assessment of the cloud provider's performance, which can be assessed using KPIs. The future plans to expand the research scope and decrease some of the limitations mentioned earlier are further discussed in the following future work section.

## 8.4 Future work

This section presents some potential future directions for this research. Some identified directions are mentioned below, including various potential methodologies, future contexts and enhancement techniques.

### 8.4.1 CMRA model and factor analysis

In this research, the proposed AHP technique was limited to pair compare the six main readiness criteria in CMRA instrument. In the future, the technique can be utilised to compare the importance of the readiness criteria and their relevant PQs. Alternatively, the importance and strength of relationships of all the RCs and their PQs can be explored and confirmed by using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) techniques. Structured Equation Modelling (SEM) is a confirmatory statistical model for hypothesis testing that allow the analysis of structural relationships between measured variables and latent construct (Byrne, 2013). The SEM technique comprises factor analysis technique and multiple regression analysis. The SEM model allows the researchers to execute a series of statistical tests to explore and confirm the complex relationships between the independent and dependant variables within the model (Suhr, 2006).

These techniques require a large sample size to validate the model outcome (Byrne, 2013). This can be achieved by distributing a questionnaire to IT specialists and experts in various organisations across Saudi Arabia. This may include ministries, corporate organisations, enterprises and research institutes. The benefit of this technique would be to generalise the resultant model to make it applicable to any future work. A potential implication of this model would enable the users to employ the model for cloud migration purposes.

### 8.4.2 Automation and benchmarking

Another future approach is to use the radar chart as a benchmarking measure against the best-performing organisation. In Figure 8-1, three assessments of the three organisations are shown with the best-performing organisation labelled as the benchmark (in blue). This technique shows the organisation its standing relative to similar organisations in the same domain.

The CMRA tool as it now stands is an online questionnaire with its decision-making logic based upon users' feedback. To facilitate automation, the tool can be extended as an online assessment tool that would be able to evaluate, generate, save and retrieve model results on demand. For instance, it would allow registered users to access a remote server to use the tool, assess their organisation and generate the results in real time via charting and other statistical APIs (e.g. via Google Charting API).

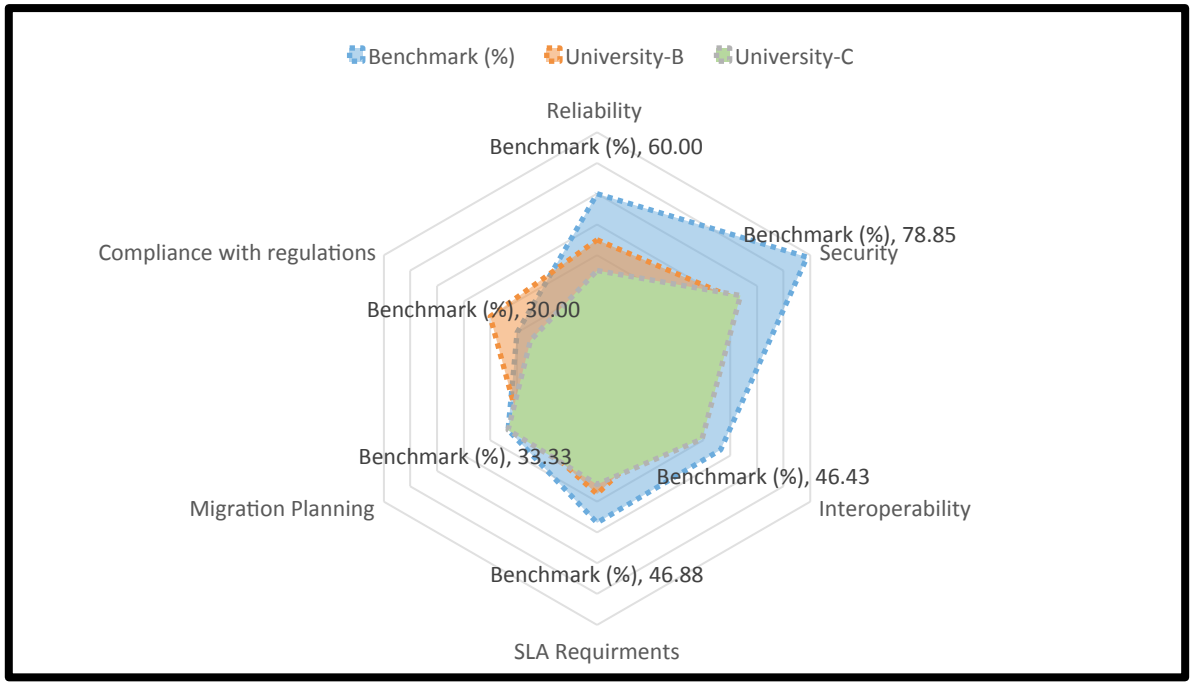


Figure 8-1: CMRA as benchmarking tool

One major extension to the tool originates in the Artificial Intelligence (AI) domain. Based on data gathered from different universities, various AI algorithms can be used to design and optimise the outcome of this tool. For instance, user input-output pairs can be used to train either a fuzzy inference mechanism or an artificial neural network to create a prediction tool that would be capable of automatically assessing any organisation by using the model itself as a benchmarking criterion to model unseen cases by statistical training.

The validated CMRA instrument would now be formulated into a rule-based fuzzy inference system (FIS) drawing knowledge from the CMRA instrument (Czogala, 2000). The following description explains the design of a FIS to predict the readiness of different universities based on its responses to a set of questions relevant to the CMRA readiness criteria (RCs). The stages are described in details below:

### Step 1: FIS membership functions:

The membership functions form an integral part of the fuzzy rule-based methodology for the prediction of 'Readiness' output variable to migrate to the cloud paradigm. A set of questions representing each CSF would be the input variables and would be decided at this stage. Each variable (CSF) will consist of five sets (levels) e.g. Very High (VH), High (H), Moderate (M), Low (L) and Very Low (VL). The stage will also involve mathematically formulating and applying a fuzzy implication method (e.g. Product, Min, BDIF, BSUM) to obtain the final score (Baczynski & Jayaram, 2008).

**Step 2: Design of a rule-base to predict the FIS 'Readiness' criterion:**

Based on the expert input, the total number of rules will be decided and hence the time duration to complete this stage is the longest. The rules will be used to combine the overall membership functions to generate a single fuzzy Readiness outcome (Yildiz, 2010, p.4). In fuzzy logic, the rules are primarily used to combine the membership functions to generate a single output variable, which in this case is the Readiness score. There could be a case where the number of questions deemed important by the experts (covering each) RC is very high. Hence, the rules will be created selectively based on expert input.

**Step 3: Development of a defuzzification system:**

Based on the two earlier stages, a decision will be made to select from a number of methods e.g. Centre of Gravity, Centre of Gravity for Singletons, Left Most Maximums and Right Most Maximum in order to aggregate individual membership function (variables) outcomes, this stage will involve aggregating separate membership functions into a single crisp (defuzzified) Readiness score (Jamshidi, 2008).

**Step 4: FIS Output Calibration:**

The initial score is obtained in a fuzzy form, which would be a value between 0 and 1. In order to get a crisp (calibrated) value, a number of methodologies are presented in the literature, which utilise existing system data to calibrate the underlying fuzzy logic mechanism. The calibration in fuzzy logic is effectively a process of transforming membership degrees of various variables (i.e. RCs) into a specific real-world decision.

The calibration of the FIS outcome can be achieved via some supervised machine learning methods such as an Artificial Neural Network (ANN). Based on a set of real-world test cases, an ANN can be used to calibrate the membership functions to automatically generate a rule-base fit for the prediction of the Readiness score. The technique is generally known as the Adaptive Neuro Fuzzy Inference System (ANFIS) (Lima et al., 2002).

### 8.4.3 Extending CMRA to a wider context

The CMRA model was originally proposed to measure the readiness status at this stage. In future, the model can be extended to improve the readiness of an organisation by providing guidelines on the various steps and measures to be undertaken in the form of a roadmap.

Since the CMRA instrument has already been applied to public Saudi universities, it can be applied to private universities. Moreover, since other Middle Eastern countries have cultural and demographical aspects in common with Saudi Arabia, the same CMRA model can be validated for these regions.

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# Appendix A

## Confirmatory Study Interview Questions

1) Does your University use cloud services now or in the Past? If not Q6
2) What type of cloud services have you used in your University?
   There are three services: a- SaaS b- PaaS c- IaaS
3) What type of cloud deployment is used in your university?

   There are four deployments: a- Hybrid b-Public c- Private D- Community

4) Did You Face challenges when you implement or migrate to the cloud?
5) Are you satisfied with the quality of services provided by the cloud?

Please choose which of the following proposed factors are important or not for successful cloud migration in Saudi Arabia Universities. For more Clarifications seeFig1 below.

| **Success Factor** | **Important / Not Important** | **Why? (Explanation)** |
|---|---|---|
| **Technological Factors: The Following factors are related to the cloud technology itself** | | |
| Reliability | | |
| Interoperability | | |
| Security & Privacy | | |
| Disaster Recovery | | |
| Bandwidth & QoS | | |
| **Organizational Factors: The following Factors are related to the University culture and management side.** | | |
| Ministry of Education Policies | | |
| Top Management Support | | |
| Users Training & Awareness | | |
| SLA Requirements | | |
| Degree of Control (data) | | |

6) What other technological Factors do you recommend to ensure successful migration to cloud computing in your University?

7) What other technological Factors do you recommend to ensure successful migration to cloud computing in your University?

8) What type of cloud models do you think is it more likely to be adopted in your university? Why?

9) Why you did not consider cloud services in your Universities so far?

10) Do you suggest further modifications for the framework categories or success factors?

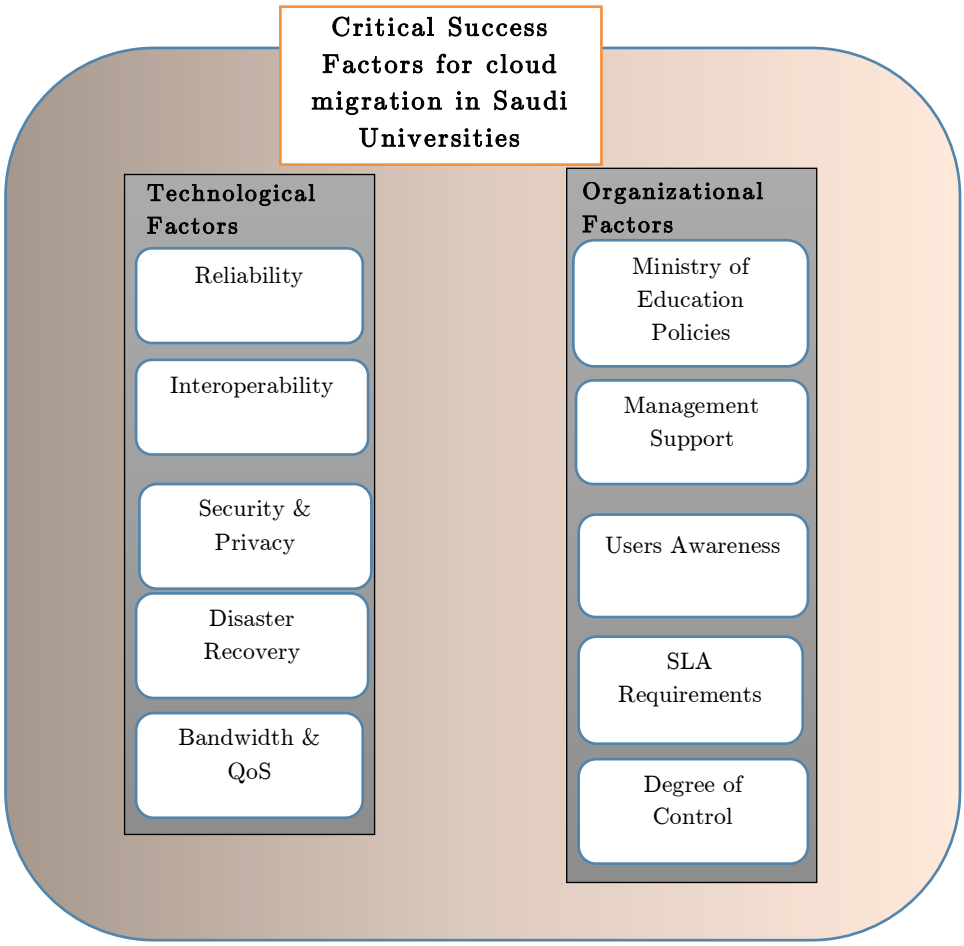



Fig1 a Proposed Framework for cloud migration in Saudi Arabia Universities

# Appendix B

## Confirmatory Study Questionnaire

The main aim of this online questionnaire is to investigate factors that may influence the successful migration of ICT services in Saudi Arabia Higher Education to cloud computing paradigm. I would appreciate your responding to the following questions. Your input will be very valuable to this study. By pressing the submit button you are agreeing to my use of your responses in my study. This questionnaire is anonymous and no personal data will be collected. Thank you for your time in completing this questionnaire. It should not take longer than fifteen minutes.

Section 1. Demographic Information and Cloud background Questions?

Question 1.1

1. Have you worked in IT Department or on IT project for any Saudi university?

- Yes
- No

Question 1.2

Please specify the category to which your university belong:

- Start-up colleges/universities (institutions less than 10 years old)
- Large universities (institutions founded more than 20 years ago)

Question 1.3

What is the total staff/student-base of your university?

- Less than 25000
- More than 25000 and less than 50 000 students and staff
- More than 50 000 and less than 100 000 students and staff
- More than 100 000 students and staff

Question 1.4

Choose the option that best reflects your IT years of experience in Saudi Universities:

- ○ No Experience
- ○ Less than 2 years
- ○ 2 - 5 Years
- ○ 6 - 10 years
- ○ More than 10 Years

Question 1.5

When do you think your university would migrate to a cloud-based setup?

- ○ Not sure
- ○ Less-than a year
- ○ 1 – 5 years
- ○ 5+ years
- ○ Already migrated

Question 1.6

What type of cloud deployments do you think is more likely or has been appropriate to be deployed in your University? (You can choose more than one option)

- ☐ In-house Private Cloud in Saudi Arabia
- ☐ Private Cloud hosted by Providers ex. Google
- ☐ Public clouds
- ☐ Community Cloud
- ☐ Hybrid Cloud: consisting of two of the previous types within the Saudi borders
- ☐ Hybrid Cloud: consisting of two of the previous types outside the Saudi

borders

## Section 2. Technological Factors Section

**The following factors are related to the technological characteristics should exist for successful migration process to the cloud. To what extent do you agree with the following statements about various technological success factors for cloud migration in Saudi Arabia Universities?**

Question 2.1

| | | | | | |
|---|---|---|---|---|---|
| The migrated services to cloud environment must be secured **(SE1)** | ○ | ○ | ○ | ○ | ○ |
| The migrated services to cloud environment guarantee privacy **(SE2)** | ○ | ○ | ○ | ○ | ○ |
| The cloud services must be reliable with high up time **(RE1)** | ○ | ○ | ○ | ○ | ○ |
| The services based on the cloud must be reliable to handle the services workload **(RE2)** | ○ | ○ | ○ | ○ | ○ |
| The migrated system must be capable of soundly handling disasters by providing recovery plans **(RE3)** | ○ | ○ | ○ | ○ | ○ |
| The system must have interoperability with different system interfaces and Internet capable devices **(IN1)** | ○ | ○ | ○ | ○ | ○ |
| The system must have interoperability with different Internet capable devices **(IN2)** | ○ | ○ | ○ | ○ | ○ |
| The migrated services should be compatible with the existing IT Systems in the universities **(IN3)** | ○ | ○ | ○ | ○ | ○ |
| Internet Bandwidth has an important role in such a migration **(RE4)** | ○ | ○ | ○ | ○ | ○ |
| Awareness of physical location of the services that are migrated has an important role in the process **(SE3)** | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| A system capable of extending based on user requirements and work load is also counted as a critical success factor **(IN4)** | ○ | ○ | ○ | ○ | ○ |

## Section 3. Organizational success Factors

**The following factors are related to the organizational management (Behavioural) aspects for successful migration process to the cloud. To what extent do you agree with the following factors are important for successful cloud migration in Saudi Arabia Universities?**

Question 3.1

| | | | | | |
|---|---|---|---|---|---|
| Government cloud usage policies a are required to protect data on the cloud **(CR1)** | ○ | ○ | ○ | ○ | ○ |
| Government cloud usage standards are required to protect the identities of stakeholders using the cloud **(CR2)** | ○ | ○ | ○ | ○ | ○ |
| The design of strategy plan forms a crucial part of cloud-based migrated systems **(MP1)** | ○ | ○ | ○ | ○ | ○ |
| The migrated cloud system should comply with the Saudi regulations **(CR3)** | ○ | ○ | ○ | ○ | ○ |
| Universities should have a strong knowledge base about the various cloud-service options (**MP2)** | ○ | ○ | ○ | ○ | ○ |
| Universities should have a strong knowledge base about the various cloud-service providers (**MP3)** | ○ | ○ | ○ | ○ | ○ |
| Technical support should be well integrated in the migrated system to provide assistance to the end-users (**SL1)** | ○ | ○ | ○ | ○ | ○ |
| Top management support should form a part of the migrated cloud system (**MP4)** | ○ | ○ | ○ | ○ | ○ |
| The IT technical staff should be appropriately trained in order for the system migration to be | ○ | ○ | ○ | ○ | ○ |

successful (**MP5)**

| | | | | | |
|---|---|---|---|---|---|
| For a successful migration the SLA requirements by the Saudi University must be stated and communicated clearly to the Cloud Provider (**SL2)** | ○ | ○ | ○ | ○ | ○ |
| The Data of the educational cloud services should be under the control of the University to make the migration a success **(CR4)** | ○ | ○ | ○ | ○ | ○ |
| Integrated Arabic language support in the migrated system will make the system more successful (**SL3)** | ○ | ○ | ○ | ○ | ○ |
| For successful migration to educational cloud based services, the educational cloud services stakeholders sensitive data should be under the control of the University such as patient records or students grades **(CR5)** | ○ | ○ | ○ | ○ | ○ |

# Appendix C

## CAMRA Content Validation

The main aim of this expert interview is to confirm the appropriateness and relevance of the measuring success factor items (Processes) that belongs to the six-cloud migration organisation self-readiness assessment criteria: Reliability, Security, Interoperability, SLA requirements, Migration plan and Compliance with regulations. I would appreciate your responding to the following questions. Your input will be very valuable to this study. The interview outcome will be treated anonymously and no personal data will be collected. Thank you for your time in completing this questionnaire. It should not take longer than fifteen minutes.

### Section 1:

What is your IT project Cloud Computing experience, either in cloud migration process or any cloud related fields (in Years):

- Less than a year
- 1 -5
- More than 5

What is your cloud expertise job role?

☐ Cloud Architect

☐ Cloud Software Engineer

☐ Cloud Software Developer

☐ Cloud System Administrator

☐ Cloud Systems Engineer

☐ Cloud Security Specialist

☐ Cloud Integration Specialist

☐ None

Other (please specify)

**Section2:** The developed measuring items for each assessment criteria

Measuring items for Infrastructure reliability readiness criterion (Bandwidth, disaster recovery and availability)

| To what extent do you agree that the following measuring items are relevant to measure the readiness of the organisation infrastructure reliability criterion? | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| 1. The implementation of recovery techniques e.g. (via redundancy datacentre, network, backups) for the services affected by disasters or failures | | | | | |
| 2. The Calculation of the organisation required network bandwidth for hosting/running all the organisation services on the cloud | | | | | |
| 3. The assessment of the data latency rate of the migrated services (which services accept High latency/ and which require Low latency) | | | | | |
| 4. The identification of the required services high up time (availability requirements) e.g. 24/7 or certain working hours or days | | | | | |
| 5. The provision of techniques to guarantee best time possible to recover different failed services | | | | | |
| 6. The measurement of the services workload spikes during certain times of the day, month or academic semester | | | | | |

Do you think there is any overlapping between these items mentioned above?

Comments:

Do you think there are other important measuring items not above? If yes, what are they please?

Comments:

2. Measuring items for Security readiness criterion (Privacy, Identification, Authentication, Authorization)

| To what extent do you agree that the following measuring items are relevant to measure the readiness of the organisation infrastructure reliability criterion? | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| The awareness of security risks associated with migrating the resources to the cloud e.g. (Vendor lock-in, data leakage, multi-tenancy attacks) | | | | | |
| The categorisation of the critical mission services (security-sensitive) and non-sensitive services | | | | | |
| The selection of cloud deployments and services based on the organisation security requirements | | | | | |
| The evaluation of data centre protection e.g. (building safety) either in the organisation or in the provider location | | | | | |
| The implementation / awareness of the privacy controls required to the information on the cloud e.g. (Encryption algorithms, password length) | | | | | |
| The documentation of overall security requirements (Policies) for the migrated services | | | | | |
| The capabilities of validating all the system stakeholders' credentials | | | | | |
| The assurance of Information protection against the unauthorized accesses e.g. (employing security protocol SSL/TLS, access control list) | | | | | |
| The restriction of accessing the data is sufficient | | | | | |
| The capability to keep the information protected from the unauthorised modifications by employing cryptographic methods such as comparing the received data hash with the hash of the original message) | | | | | |
| The controls applied to prevent users and parties to deny after participation in any interaction such as communications, transactions among parties e.g (Proof of transaction attributes such as Date, time and identity of interacting parties) | | | | | |
| The controls applied to detect the malicious activities e.g. (Firewalls, Honeypots and intrusion detections) | | | | | |
| The assessment of the all security mechanisms if they work, update properly and do the required security goals and policies | | | | | |
| The adoption of information security standards e.g. "ISO/IEC27001" and "COBIT5" | | | | | |

Do you think there is any overlapping between these items mentioned above?

Comments:

Do you think there are other important measuring items not above? If yes, what are they please?

3. Measuring items for Interoperability readiness criterion (Flexibility, Scalability, Portability)

| To what extent do you agree that the following measuring items are relevant to measure the readiness of the organisation infrastructure interoperability criterion? | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| The Examination of the organisation data portability e.g. (the format of the organisation data are compatible with the potential cloud provider data type) | | | | | |
| The identification of the required level of interobiliapility for the migrated application based on the service models (SaaS, PaaS and IaaS) | | | | | |
| The awareness of standards to ensure interoperability of applications on the cloud e.g. (Open virtualisation Format(OVF), Cloud Data Management interface (CDMI)) | | | | | |
| The evaluation of whether the migrated applications are leveraging SOA design principles | | | | | |
| The consideration of implementing Enterprise Service Bus (ESB) to perform interface, protocol and data transformations to address differences between different cloud providers | | | | | |
| The identification of the organisation's applications architecture that support scaling out to multiple servers | | | | | |
| The recognition of the organisation legacy systems that require special access to hardware components | | | | | |

Do you think there is any overlapping between these items mentioned above?

Comments:

Do you think there are other important measuring items not above? If yes, what are they please?

Comments:

4. Measuring items for SLA Requirements readiness criterion (Technical support level, Arabic language support, service level requirements)

| To what extent do you agree that the following measuring items are relevant to measure the readiness of the organisation SLA requirements criterion? | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| Defining the negotiable / non-negotiable issues related to contracts, SLA and pricing model | | | | | |
| The different services levels required for the migrated services to the cloud are identified e.g. (the expected availability time or locations) | | | | | |
| The security requirements are customised for each service migrated to the cloud e.g.(the ability to manage security terms in the cloud SLA) | | | | | |
| The technical support required are identified and can be negotiated with the service provider e.g. (Help desk in the organisation, multilingual support or several offices) | | | | | |
| The evaluation of different SLAs from different cloud service providers | | | | | |
| The identification of the services that need customisation e.g.(the adaptation of Arabic language in user interfaces or support accessibility needs) | | | | | |
| The documentation of the required compensation and remediation when fault and failure occur e.g.(the penalties required if the guaranteed service level is not met) | | | | | |
| Defining the satisfied cost requirements for the services migrated e.g. (cost of: VM, one unit of CPU unit, storage, RAM and network) | | | | | |
| The establishment of the cloud request for proposal (RFP) document (tender documentation) | | | | | |
| Defining the accepted get-out or exit procedures and clauses e.g.(the time to move to another cloud provider or how to make sure the data is removed from the provider storage ) | | | | | |

Do you think there is any overlapping between these items mentioned above?

Comments:

Do you think there are other important measuring items not above? If yes, what are they please?

Comments:

5.Measuring items for Migration plan readiness criterion (Knowledge-base, IT Training and management support)

| To what extent do you agree that the following measuring items are relevant to measure the readiness of the organisation migration plan criterion? | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| Establishing the strategic intent and objectives of cloud computing within the IT strategy | | | | | |
| Identifying the services that suitable for migration to the cloud | | | | | |
| Involving the stakeholders (management board, IT staff, employee) in assessing service readiness for the cloud | | | | | |
| Gathering intelligence on cloud services and offerings e.g. (structured resources such as successful migrated projects, Experts views and vendors offers) | | | | | |
| Gathering intelligence to evaluate and select the suitable cloud vendor e.g. (adopted tool to evaluate cloud vendors such as SMICLOUD) | | | | | |
| The definition of the required IT skills to migrate to the cloud against the available skills | | | | | |
| Developing training plans to enhance internal skills to address the potential gaps | | | | | |
| Defining the suitable metrics to measure the impact of the migrated services e.g. (assessing cost savings or validate SLA compliance) | | | | | |
| The support of board of directors to cloud migration project and investment in your organisation e.g. (establishing goals for using cloud computing) | | | | | |
| The responsibility of top management for cloud migration project and decisions in your organization e.g. (vision, managing IS human resource, budget and determine all limitation and benefits) | | | | | |

Do you think there is any overlapping between these items mentioned above?

Comments:

Do you think there are other important measuring items not above? If yes, what are they please?

Comments:

6. Measuring items for Compliance with regulation readiness criterion (Degree of data control, adherence to regulations and IT outsourcing standards)

| To what extent do you agree that the following measuring items are relevant to measure the readiness of the organisation migration plan criterion? | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| IT (cloud) outsourcing policies, and regulatory requirements in your organisation | | | | | |
| The identification of the local regulatory requirements to host or outsource to cloud services e.g. (awareness of cloud usage local regulations) | | | | | |
| Defining requirements to control the data over the functionality of the cloud services e.g.(how sensitive data will be controlled) | | | | | |
| Declaration policies to regulate the usage of the data on the cloud (Data ownership policies) | | | | | |
| Identifying the cloud services and providers that adhere to the country regulations e.g. (licensed vendors) | | | | | |
| The alignment between the organisation cloud requirements and the government legal and regulatory requirements including those related to security, privacy and accessibility | | | | | |

Do you think there is any overlapping between these items mentioned above?

Comments:

Do you think there are other important measuring items not above? If yes, what are they please?

Comments:

**Section 3:** To what extent do you agree about the wording clearance and importance of the metric's scale levels presented in the following figure 1, The scale levels presented are adopted from Process assessment model (PAM) in COBIT 5 and they were adopted in CMRA as metrics to measure the readiness status of universities for cloud migration.

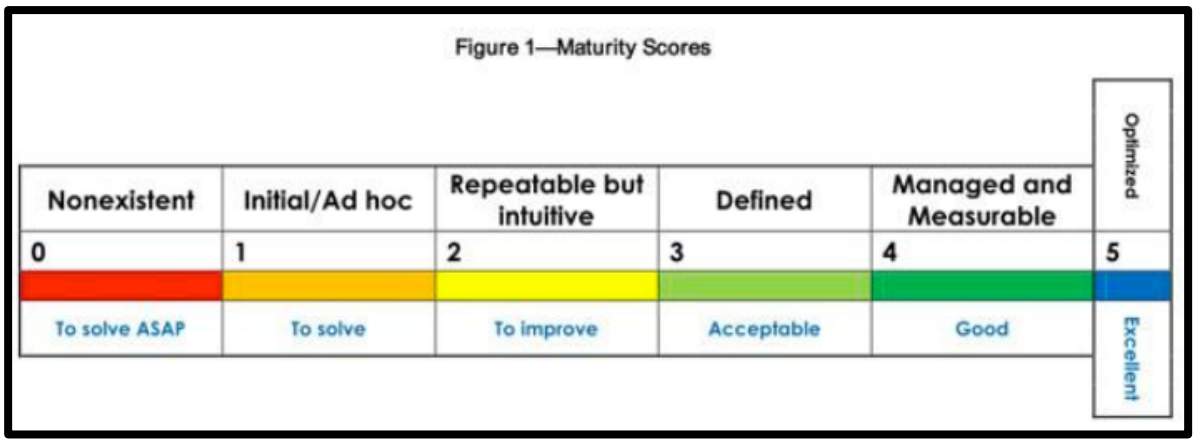



Figure 1: Maturity Scores (COBIT 5 PAM Book, 2012)

The definition of each scoring level is presented below; please rate each level wording accuracy and importance to the assessment of the readiness process:

- **Non-existent Proccess (0):** the process not implemented, thought-of or aware which indicates that "There are major issues and weakness areas and serious consideration is required before migrating to the cloud"
- Comments:
- 

- **Initial Process (1):** the process is not implemented adequately but is being considered and there is some awareness which indicates that "The process at this level is below average and require substantial improvement before migrating your system to the cloud"
- Comments:
- 

- **Repeatable Process (2):** the process is generally considered, implemented but without formal capabilities and depends on individual efforts "The process at this level remains close to reach the average and require substantial improvement before the cloud migration"
- Comments:

- 

- **Defined Process (3):** the process has an immature implementation but has defined formal capabilities which indicates that "The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration".
- Comments:

- **Managed Process (4):** the process is now implemented in managed fashion (planned, monitored, measured and adjusted) which indicates that "The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration".
- Comments:

- **Optimised Process (5):** the process is continuously improved and best practices are followed to monitor and manage the business goals which indicates that "Be persistent and no improvement required, that is, the process area is managed quite well and no action needs to be taken before considering the migration process".
- Comments:

# Appendix D

## Research Ethics Forms

### A. Confirmatory Study Ethical Approval Forms

### 1. Participant Information

**Participant Information Sheet**

**Study Title:** A Review and confirmation of a success factors framework for cloud migration in Saudi Arabia Universities

**Researcher:** Abdulrahman Alharthi

**Ethics number:** 15707

Please read this information carefully before deciding to take part in this research. If you are happy to participate you will be asked to sign a consent form.

**What is the research about?**

This research is required as part of the researcher's PhD degree in computer science. The aim of this research is to investigate factors that influence the successful migration of cloud in Saudi Arabia Universities. For the implementation of this research, you are invited to participate in an interview or an online survey. This interview or survey focuses on the critical success factors for cloud migration in Saudi Arabia Higher Education.

**Why have I been chosen to participate?**

You are invited to participate in this study because you are an IT expert working in a Saudi University. Your opinion and expertise will help in improving the constructed framework.

**What will happen to me if I take part?**

The semi-structured interviews will present you with questions about the success factors for cloud migration in Saudi Arabia higher education.

**Are there any benefits in my taking part?**

This research is not designed to help you personally, but your feedback will help me gather expert opinions on the development efforts.

**Will my participation be confidential?**

Yes. Your data and that of other participants will be stored and used on secure systems. Any stored data will not be linked to your name. Any information related to your University will not be disclosed.

### Are there any risks involved?

No.

### What happen if I change my mind?

You have the right to terminate your participation in the research and request data deletion, at any stage, you do not need to give any reasons, and without your legal rights being affected. Any data collected form you will be immediately destroyed.

### Where I can get more information?

the unlikely case of concern or complaint, please contact Research Governance Manager (02380 595058, rgoinfo@soton.ac.uk). For further details, please contact my study supervisors, Dr Robert Walters and Dr Gary Wills or me.

**Investigator:** Abdulrahman Alharthi: aaa2g14@ecs.soton.ac.uk

**Supervisor:** Dr Robert Walters: rjw1@ecs.soton.ac.uk

**Supervisor:** Dr Gary Wills: gbw@ecs.soton.ac.uk

## 2. Consent Forms

- **Consent Form for the Interview**

| Ethics reference number: **ERGO/FBSE/15707** | Version: 1 | Date: 2015-06-10 |
|---|---|---|
| Study Title: A Review of a success factors framework for cloud migration in Saudi Arabia Universities | | |
| Investigator: Abdulrahman Alharthi | | |

Please initial the box(es) if you agree with the statement(s):

| | |
|---|---|
| I have read and understood the Participant Information (version 1 dated 2015-06-10) and have had the opportunity to ask questions about the study. | ☐ |
| I agree to take part in this study. | ☐ |
| I understand my participation is voluntary and I may withdraw at any time and for any reason. | ☐ |
| I agree to record my voice during my participation in this study | ☐ |

Data Protection

I understand that information collected and recorded during my participation in this study is completely secured and it will be stored on a password-protected computer and that this information will only be used for the purpose of this study and it will be immediately destroyed at the end of the research.

Name of participant (print name).....

Signature of participant.....

Date.....

- **Consent Form for the Questionnaire:**

| | | |
|---|---|---|
| Ethics reference number: **ERGO**/FPSE **/15707** | Version: 1 | Date: 2015-06-10 |
| Study Title: A Review of a success factors framework for cloud migration in Saudi Arabia Universities | | |
| Investigator: Abdulrahman Alharthi | | |

Please initial the box(es) if you agree with the statement(s):

I have read and understood the Participant Information (version 1 dated 2015-06-10) and have had the opportunity to ask questions about the study. ☐

I agree to take part in this study. ☐

I understand my participation is voluntary and I may withdraw at any time and for any reason. ☐

Data Protection

I understand that information collected and recorded during my participation in this study is completely secured and it will be stored on a password-protected computer and that this information will only be used for the purpose of this study and it will be immediately destroyed at the end of the research.

Name of participant (print name)……

Signature of participant……..

Date……

## B. Case Study Ethical Approval Form:

### 1. Participant Information Sheet

**Study Title:** An assessment instrument to measure the Saudi Universities' readiness for migrating to the cloud.

**Researcher:** Abdulrahman Alharthi

**Ethics number:** 24380

Please read this information carefully before deciding to take part in this research. If you are happy to participate you will be asked to sign a consent form.

### What is the research about?

This research is required as part of the researcher's PhD degree in computer science. In this stage of my PhD research, an instrument is developed to measure the readiness status of the Saudi Higher education institutions to migrate to the cloud. This instrument is based on critical success factors (CSFs), which are structured and confirmed by Saudi cloud experts and practitioners. The confirmed CSFs are expanded to related measurement (items), which were gathered and developed by utilising secondary research and implementing Goal Question Metrics Approach (GQM). For the implementation of this research, you are invited to participate in an interview or an online survey. This interview or survey focuses on the critical success factors for cloud migration in Saudi Arabia Higher Education.

### Why have I been chosen to participate?

You are invited to participate in this study because you are an IT expert working in a Saudi University or you have field and research expertise in cloud computing. Your opinion and expertise will help in reviewing the instruments' measuring items or conducting a readiness status assessment in the university you work in.

### What will happen to me if I take part?

The semi-structured interviews will present you with questions to review the relevance of the measuring items proposed to measure the cloud migration self-readiness of any educational institutions. The online questionnaire will present you with assessment instrument to measure your university readiness status to migrate to the cloud and to provide feedback to evaluate the used instrument in the study.

### Are there any benefits in my taking part?

This research is not designed to help you personally, but your feedback will help me gather expert opinions on the development efforts and provide you with insights about your university readiness status before migrating to the cloud.

### Will my participation be confidential?

Yes, Any data will be stored will not be linked to your name or to your organisation's name. Your data and that of other participants will be stored and used on secure systems.

### Are there any risks involved?

No.

### What happen if I change my mind?

You have the right to terminate your participation in the research and request data deletion, at any stage, you do not need to give any reasons, and without your legal rights being affected. Any data collected form you will be immediately destroyed.

### Where I can get more information?

In the unlikely case of concern or complaint, please contact Research Governance Manager (02380 595058, rgoinfo@soton.ac.uk). For further details, please contact my study supervisors, Dr Robert Walters and Dr Gary Wills or me.

**Investigator:** Abdulrahman Alharthi: aaa2g14@ecs.soton.ac.uk

**Supervisor:** Dr Robert Walters: rjw1@ecs.soton.ac.uk

**Supervisor:** Dr Gary Wills: gbw@ecs.soton.ac.uk

## 2. Consent Forms

- **Consent Form for the Interview (Group one)**

| Ethics reference number: **ERGO**/FBSE/**24380** | Version: 1 | Date: 2016-11-13 |
|---|---|---|
| Study Title: An assessment instrument to measure the Saudi Universities' readiness for migrating to the cloud. | | |
| Investigator: Abdulrahman Alharthi | | |

Please initial the box(es) if you agree with the statement(s):

I have read and understood the Participant Information (version 1 dated 2016-11-13) and have had the opportunity to ask questions about the study. ☐

I agree to take part in this study. ☐

I understand my participation is voluntary and I may withdraw at any time and for any reason. ☐

I agree to record my voice during my participation in this study ☐

Data Protection

I understand that information collected and recorded during my participation in this study is completely secured and it will be stored on a password-protected computer and that this information will only be used for the purpose of this study and it will be immediately destroyed at the end of the research.

Name of participant (print name)……

Signature of participant……..

Date……

- **Consent Form for the online instruments' Questions (Group two)**

| | | |
|---|---|---|
| Ethics reference number: **ERGO**/FPSE **/24380** | Version: 1 | Date: 2016-11-13 |
| Study Title: An assessment instrument to measure the Saudi Universities' readiness for migrating to the cloud. | | |
| Investigator: Abdulrahman Alharthi | | |

Please initial the box(es) if you agree with the statement(s):

| | |
|---|---|
| I have read and understood the Participant Information (version 1 dated 2016-11-13) and have had the opportunity to ask questions about the study. | ☐ |
| I agree to take part in this study. | ☐ |
| I understand my participation is voluntary and I may withdraw at any time and for any reason. | ☐ |

Data Protection

I understand that information collected and recorded during my participation in this study is completely secured and it will be stored on a password-protected computer and that this information will only be used for the purpose of this study and it will be immediately destroyed at the end of the research.

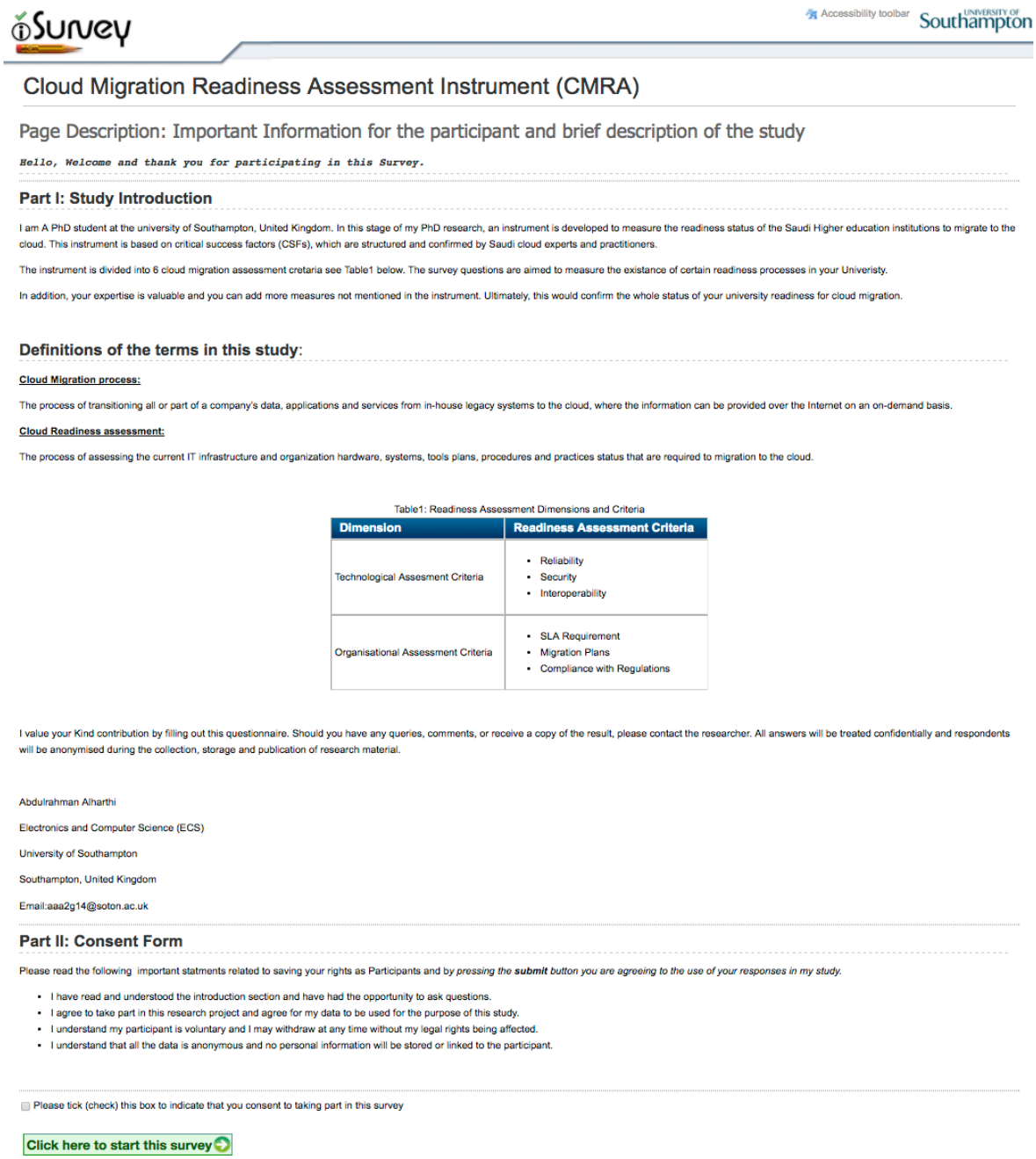
Name of participant (print name)……

Signature of participant……..

Date……

# Appendix E

## CAMRA Instrument Questions



iSurvey

Accessibility toolbar University of Southampton

### Cloud Migration Readiness Assessment Instrument (CMRA)

Page Description: Important Information for the participant and brief description of the study

***Hello, Welcome and thank you for participating in this Survey.***

**Part I: Study Introduction**

I am A PhD student at the university of Southampton, United Kingdom. In this stage of my PhD research, an instrument is developed to measure the readiness status of the Saudi Higher education institutions to migrate to the cloud. This instrument is based on critical success factors (CSFs), which are structured and confirmed by Saudi cloud experts and practitioners.

The instrument is divided into 6 cloud migration assessment cretaria see Table1 below. The survey questions are aimed to measure the existance of certain readiness processes in your Univeristy.

In addition, your expertise is valuable and you can add more measures not mentioned in the instrument. Ultimately, this would confirm the whole status of your university readiness for cloud migration.

**Definitions of the terms in this study:**

**Cloud Migration process:**

The process of transitioning all or part of a company's data, applications and services from in-house legacy systems to the cloud, where the information can be provided over the Internet on an on-demand basis.

**Cloud Readiness assessment:**

The process of assessing the current IT infrastructure and organization hardware, systems, tools plans, procedures and practices status that are required to migration to the cloud.

Table1: Readiness Assessment Dimensions and Criteria

| Dimension | Readiness Assessment Criteria |
|---|---|
| Technological Assesment Criteria | • Reliability<br>• Security<br>• Interoperability |
| Organisational Assessment Criteria | • SLA Requirement<br>• Migration Plans<br>• Compliance with Regulations |

I value your Kind contribution by filling out this questionnaire. Should you have any queries, comments, or receive a copy of the result, please contact the researcher. All answers will be treated confidentially and respondents will be anonymised during the collection, storage and publication of research material.

Abdulrahman Alharthi

Electronics and Computer Science (ECS)

University of Southampton

Southampton, United Kingdom

Email:aaa2g14@soton.ac.uk

**Part II: Consent Form**

Please read the following important statments related to saving your rights as Participants and by *pressing the **submit** button you are agreeing to the use of your responses in my study.*

- I have read and understood the introduction section and have had the opportunity to ask questions.
- I agree to take part in this research project and agree for my data to be used for the purpose of this study.
- I understand my participant is voluntary and I may withdraw at any time without my legal rights being affected.
- I understand that all the data is anonymous and no personal information will be stored or linked to the participant.

☐ Please tick (check) this box to indicate that you consent to taking part in this survey

Click here to start this survey

**1. Demographic Information and Cloud background Questions**

1. Please specify the category to which your university belong:

- ○ Start-up colleges/universities (institutions less than 10 years old)
- ○ Large universities (institutions founded more than 20 years ago)

2. Choose the option that best reflects your IT years of experience in Saudi Universities:

- ○ No Experience
- ○ Less than 2 years
- ○ 2 - 5 Years
- ○ 6 - 10 years
- ○ More than 10 Years

3. How confident are you about the readiness of your University for migrating their ICT services to the cloud?

| Not confident | 1 | 2 | 3 | 4 | 5 | Fully confident |
|---|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ | |

4. Which of the following in your view are the main organisational benefits for migrating to the cloud? (You can choose more than one option)

- ☐ Scalability
- ☐ Flexibility
- ☐ Collaboration
- ☐ Access to the latest technology and services
- ☐ Integrated IT Services (no need for installtion, set up, and management)
- ☐ None
- ☐ Others

5. Which of the following in your view are the potential challenges the University will face when migratig to the cloud?

- ☐ Lack of cloud-related knowledge
- ☐ The process of selection of cloud provider is complex
- ☐ Lack of decision support tools
- ☐ Change of system management and impact on organisation
- ☐ Legal implication
- ☐ None
- ☐ Others

6. Which of the following are the most valuable sources of information your univeristy followed before migrating to the cloud?

- ☐ Documented Projects
- ☐ Expert views
- ☐ Vendors offers
- ☐ White Papers
- ☐ Cloud decision support systmes
- ☐ None
- ☐ Others

7. What is your IT expertise job roles: **(You can choose more than one)**

- ☐ IT Architect
- ☐ IT Software Engineer
- ☐ IT System Adminstator
- ☐ IT Project Manager
- ☐ IT Security Specialist
- ☐ None
- ☐ Others

8. Please select the Infrastructure services that your University are expected to migrate to: **(You can choose more than one)**

- [ ] Enterprise Storage
- [ ] Server Virtualisation
- [ ] Remote access/ Virtual Desktop
- [ ] Telephony
- [ ] Unified Communications
- [ ] None
- [ ] Others

9. Please select the Platform services that your University are expected to migrate to: **(You can choose more than one)**

- [ ] Database
- [ ] Business Intelligence Tools
- [ ] Service Management/Monitoring
- [ ] Enterprise Resource Planning
- [ ] None
- [ ] Others

10. Please select the Software services that your University are expected to migrate to: **(You can choose more than one)**

- [ ] Intranet
- [ ] Extranet
- [ ] CRM
- [ ] .net Apps
- [ ] None
- [ ] Others

## 2. Infrastructure Reliability Readiness

### Section Description:

**The following questions pertain to the readiness of the University to ensure relaible infrastructue before migrating to the cloud. The reliability here is defiend as:**

*"The organisation preparation and awareness to ensure that the migrated systems or services to the cloud operate its required functions without failure during specified workload time and conditions, this includes issues related to network bandwidth, disaster recovery, availability"*

**** The Rating score involves five levels of the process as follows:**

**Level 0 Non-existent process:** the process not implemented, thought-of or aware.

**Level 1 initial/incomplete:** the process is not implemented adequately but is being considered and there is some awareness.

**Level 2 defined/ performed process:** the process has an immature implementation but has defined formal capabilities.

**Level 3 Managed process:** the process is now implemented in managed fashion (planned, monitored, measured and adjusted).

**Level 4: optimised process:** the process is continuously improved and best practices are followed to monitor and manage the business goals.

- **N.B. Your comments and suggestions are very appreciated and they will be taken seriously to enhance the study.**
- **N.B. You can comment in "comment textbox" on your answer choices to explain why you choose that low or high rate, and you can suggest modification on the questions/ answers content.**

**What do you think the status of the following processes (Capabilities) in your respective University?**

1. The provision of recovery techniques e.g. (via redundancy datacentre, network, backups) for the services affected by disasters or failures

**Non-existent Process: (0% Not provided at all)**

**Initial/Incomplete Process: (25% Partially Provided)**

**Defined/Performed: (50% Half Provided**

**Managed Process: (75% Almost Provided)**

**Optimised Process: (100% Fully Provided)**

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

2. The calculation of the organisation required network bandwidth for hosting/running all the organisation services on the cloud

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

3. The assessment of the data latency rate of the migrated services (which services accept high latency/ and which require low latency

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

4. The identification of the required high up time for all the University IT services (availability requirements) e.g. 24/7 or certain working hours or days

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

5. The capability of identifying the system's workload spike times , e.g (during certain hours of the day, month or academic semester)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

6. Do you suggest adding more items to measure "Infrastructure Reliability Readiness" in your University or any other comments? if yes, what are they? you can also suggest modifying any items in this section.

**3. Security Practices Readiness**

## Section Description:

**The following questions pertain to the readiness of the University to ensure Secure infrastructue before migrating to the cloud. The Security here is defiend as:**

* The set of security controls and activities required to keep the organisation migrated hardware, software and data to the cloud protected against threats or attacks from unauthorised entity, malicious software, and attacks on the hardware and the Internet. *

** **The Rating score involves five levels of the process as follows:**

**Level 0 Non-existent process:** the process not implemented, thought-of or aware.

**Level 1 initial/incomplete:** the process is not implemented adequately but is being considered and there is some awareness.

**Level 2 defined/ performed process:** the process has an immature implementation but has defined formal capabilities.

**Level 3 Managed process:** the process is now implemented in managed fashion (planned, monitored, measured and adjusted).

**Level 4: optimised process:** the process is continuously improved and best practices are followed to monitor and manage the business goals.

- **N.B. Your comments and suggestions are very apperciated and they will be taken seriously to enhance the study.**
- **N.B. You can comment in "comment textbox" on your answer choices to explain why you choose that low or high rate, and you can suggest modification on the questions/ answers content.**

## What do you think the status of the following processess (Capapilities) in your respective University?

1. The awareness of security risks associated with migrating the resources to the cloud e.g. (vendor lock-in, data leakage, multi-tenancy attacks, different security jurisdications)

**Non-existent Process: (0% Not aware at all)**

**Initial/Incomplete Process: (25% Partially aware)**

**Defined/Performed: (50% Half aware**

**Managed Process: (75% Almost aware)**

**Optimised Process: (100% Fully aware)**

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

2. The categorisation of the critical mission IT services (security-sensitive and non-sensitive services).

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

3.The allignment between the selection of the different cloud deployment models (Public, Private, Community and Hybrid) and service models (IaaS, PaaS and SaaS), and your University security requirements.

**Non-existent Process: (0% No allignment at all)**

**Initial/Incomplete Process: (25% Partially allignment)**

**Defined/Performed: (50% Half allignment)**

**Managed Process: (75% Almost Fully alignment)**

**Managed Process: (100% Fully alignment)**

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

4. The evaluation of data centre protection level e.g. (building safety, location safety) either in the University or in the provider location.

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

5. The implementation or awareness of the privacy controls required for the information on the cloud e.g. (Encryption algorithms, password length)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

6. The documentation of overall security requirements (Policies) for the migrated services.

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

7. The assessment of the all security mechanisms if they work, update properly and do the required security goals and policies

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

8. The capability of validating (authenticating) all the system stakeholders' credentials .

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

9. The assurance of information protection against the unauthorized accesses e.g. (employing security protocol SSL/TLS, access control list)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

10. The capability to keep the information protected from the unauthorised modifications by employing cryptographic methods such as (comparing the received data hash with the hash of the original message)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

11. The controls applied to prevent users and parties to deny after participation in any interaction such as communications, transactions among parties e.g (Proof of transaction attributes such as Date, time and identity of interacting parties)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

12. The controls applied to detect the malicious activities e.g. (Firewalls, Honeypots and intrusion detections)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

13. The adoption of information security standards e.g. "ISO/IEC27001" and "COBIT5" in IT departments in your Univeristy.

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

14. Do you suggest adding more items to measure "Security Practices Readiness" in your University or any other comments? if yes, what are they? you can also suggest modiyfing any items in this section.

**4. IT systems Interoperability Readiness**

## Section Description:

**The following questions pertain to the readiness of the University to ensure portable and interoperable IT services before migrating to the cloud. The Interoperability here is defiend as:**

"The set of preparations and evaluation activities performed by the organisation to assess the ability of their systems and services to exchange information and mutually use the information with different cloud service providers in order to cooperate and interoperate with each other."

**** The Rating score involves five levels of the process as follows:**

**Level 0 Non-existent process:** the process not implemented, thought-of or aware.

**Level 1 initial/incomplete:** the process is not implemented adequately but is being considered and there is some awareness.

**Level 2 defined/ performed process:** the process has an immature implementation but has defined formal capabilities.

**Level 3 Managed process:** the process is now implemented in managed fashion (planned, monitored, measured and adjusted).

**Level 4: optimised process:** the process is continuously improved and best practices are followed to monitor and manage the business goals.

- **N.B. Your comments and suggestions are very apperciated and they will be taken seriously to enhance the study.**
- **N.B. You can comment in "comment textbox" on your answer choices to explain why you choose that low or high rate, and you can suggest modification on the questions/ answers content.**

## What do you think the status of the following processess (Capapilities) in your respective University?

1. The evaluation of the organisation data portability e.g. (the format of the organisation data are compatible with the potential cloud provider data type).

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

2. The identification of the required level of interoperability for the migrated applications based on the service models ( Low level SaaS, Meduim level PaaS and high level IaaS)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

3. The awareness of standards to ensure interoperability of applications on the cloud e.g. (Open virtualisation Format(OVF), Cloud Data Management interface (CDMI)).

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

4. The consideration of implementing Enterprise Service Bus (ESB) to perform interface, protocol and data transformations to address differences between different cloud providers.

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

5. The evaluation of whether the migrated applications are leveraging SOA design principles.

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

6. The identification of the organisation's applications architecture that support scaling out to multiple servers.

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

7. The recognition of the organisation legacy systems that require special access to hardware components

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

8. Do you suggest adding more items to measure "IT systems Interoperability readiness" in your University or any other comments? if yes, what are they? you can also suggest modifying any items in this section.

**5. Readiness of Service Level Agreement (SLA) Requirements**

## Section Description:

**The following questions pertain to the readiness of the University to ensure relaible infrastructue before migrating to the cloud. The Interoperability here is defiend as:**

"The prepared list of customised service level agreement requirements for each migrated service by the organisation in order to indicate them in the SLA to cover the end-user experience and the customer's operations."

**** The Rating score involves five levels of the process as follows:**

**Level 0 Non-existent process:** the process not implemented, thought-of or aware.

**Level 1 initial/incomplete:** the process is not implemented adequately but is being considered and there is some awareness.

**Level 2 defined/ performed process:** the process has an immature implementation but has defined formal capabilities.

**Level 3 Managed process:** the process is now implemented in managed fashion (planned, monitored, measured and adjusted).

**Level 4: optimised process:** the process is continuously improved and best practices are followed to monitor and manage the business goals.

- **N.B. Your comments and suggestions are very apperciated and they will be taken seriously to enhance the study.**
- **N.B. You can comment in "comment textbox" on your answer choices to explain why you choose that low or high rate, and you can suggest modification on the questions/ answers content.**

## What do you think the status of the following processess (Capapilities) in your respective University?

1. The identification of the required levels of services for the migrated services to the cloud e.g. (the expected availability time or locations).

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

2. The customisation of security requirements for each service migrated to the cloud e.g.(the ability to manage security terms in the cloud SLA)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

3. The technical support requirements are prepared and can be negotiated with the service provider e.g. (Help desk in the organisation or multilingual support).

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

4. The identification of the services that required customisation e.g.(the adaptation of Arabic language in user interfaces or support accessibility needs)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

5. The documentation of the required compensation and remediation when fault and failure occur e.g.(the penalties required if the guaranteed service level is not met)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

6. Defining the satisfied cost requirements for the services migrated e.g. (accepted cost for: one unit of CPU unit, storage, RAM and network for each VM used).

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

7. The establishment of the cloud request for proposal (RFP) document (tender documentation).

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

8. Defining the accepted get-out or exit procedures and clauses in the SLA contract e.g.(the time to move to another cloud provider or how to make sure the data is removed from the previous provider storage )

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

9. Do you suggest adding more items to measure " the readiness of SLA requirements" in your University or any other comments? if yes, what are they? you can also suggest modifying any items in this section.

**6. Readiness of University Migration Planning Activities**

## Section Description:

**The following questions pertain to the readiness of the University to ensure appropirate planning before migrating to the cloud. The Migration Plan here is defiend as:**

"The preparedness and planning the organisation completed before migrating their ICT services to the cloud, which involve activities such as building knowledge base, training IT staff and the support of the top management board."

**** The Rating score involves five levels of the process as follows:**

**Level 0 Non-existent process:** the process not implemented, thought-of or aware.

**Level 1 initial/incomplete:** the process is not implemented adequately but is being considered and there is some awareness.

**Level 2 defined/ performed process:** the process has an immature implementation but has defined formal capabilities.

**Level 3 Managed process:** the process is now implemented in managed fashion (planned, monitored, measured and adjusted).

**Level 4: optimised process:** the process is continuously improved and best practices are followed to monitor and manage the business goals.

- **N.B. Your comments and suggestions are very apperciated and they will be taken seriously to enhance the study.**
- **N.B. You can comment in "comment textbox" on your answer choices to explain why you choose that low or high rate, and you can suggest modification on the questions/ answers content.**

## What do you think the status of the following processess (Capapilities) in your respective University?

1. Establishing the strategic plans and objectives of cloud computing within the IT strategy

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

2. Involving the stakeholders (management board, IT staff, employee) in assessing service readiness for the cloud

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

3. Gathering intelligence on cloud services and providers offerings e.g. (structured resources such as successful migrated projects, Experts views, using evaluating tools e.g. SMICLOUD)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

4. The identitfication of the required IT skills to migrate to the cloud against the available skills (Developing required cloud skills Training Programs)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

5. Defining the suitable metrics to measure the impact of the migrated services e.g. (assessing cost savings or validate SLA compliance).

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

6.The support of board of directors to cloud migration project and investment in your University e.g. (Managing IS human resources,budget and objectives of cloud usage)

**Non-existent Process: (0% No Support at all)**

**Initial/Incomplete Process: (25% Partial support)**

**Defined/Performed: (50% Half support)**

**Managed Process: (75% Almost full Support)**

**Optimised Process: (100% Full Support)**

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

7. Do you suggest adding more items to measure " the readiness of Cloud Migration planning" in your University or any other comments? if yes, what are they? you can also suggest modifying any items in this section.

Survey Progress

## 7. Compliance with Regulations Readiness

### Section Description:

**The following questions pertain to the readiness of the University to ensure Compliance with national ICT outsource regultions before migrating to the cloud. The compliance with regulations here is defiend as:**

"The set of practices the organisations aware of/apply in order to comply with the country's regulations that govern cloud services usage or host. "

**** The Rating score involves five levels of the process as follows:**

**Level 0 Non-existent process:** the process not implemented, thought-of or aware.

**Level 1 initial/incomplete:** the process is not implemented adequately but is being considered and there is some awareness.

**Level 2 defined/ performed process:** the process has an immature implementation but has defined formal capabilities.

**Level 3 Managed process:** the process is now implemented in managed fashion (planned, monitored, measured and adjusted).

**Level 4: optimised process:** the process is continuously improved and best practices are followed to monitor and manage the business goals.

- **N.B. Your comments and suggestions are very apperciated and they will be taken seriously to enhance the study.**
- **N.B. You can comment in "comment textbox" on your answer choices to explain why you choose that low or high rate, and you can suggest modification on the questions/ answers content.**

### What do you think the status of the following processess (Capapilities) in your respective University?

1. The identification of the local regulatory requirements to host or outsource to cloud services e.g. (awareness of cloud usage local regulations)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

2. Declaration policies to regulate the usage of the data on the cloud (Data ownership policies)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

3. Identifying the cloud services and providers that adhere to the country regulations e.g. (licensed vendors)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

4.The alignment between the organisation cloud requirements and the government legal and regulatory requirements including those related to security, privacy and accessibility

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

5. Defining the requirements to control the data over the functionality of the cloud services e.g. (how sensitive data will be controlled)

| Non-existent process | Initial process | Defined process | Managed process | Optimised process |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

6. Do you suggest adding more items to measure " the readiness of Complying with regulations" in your University or any other comments? if yes, what are they? you can also suggest modifying any items in this section.

7. Do you suggest adding more items to measure " the readiness of Complying with regulations" in your University or any other comments? if yes, what are they? you can also suggest modifying any items in this section.


Tak
Obrigado
감사합니다
Gracias
Merci
شكرا لك
Thank you
Danke
Grazie
ありがとう

# Appendix F

## CMRA Criteria Weights Using AHP

University Name:

Job Role:

Years of Experience:

Date:

Please identify which of the assessment criterion given in Table1 is more important than the other, and how much more on a scale* 1 to 9 for the following pairwise comparisons?

* Scale values: 1- Equal Importance, 3- Slight importance, 5- Strong importance, 7- Very strong importance, 9- Extreme importance.

| Table1: Readiness Assessment Dimensions and Criteria | |
|---|---|
| **Dimension** | **Readiness Assessment Criteria** |
| Technological Assessment Criteria | Reliability<br>Security<br>Interoperability |
| Organisational Assessment Criteria | SLA Requirements<br>Migration Plans<br>Compliance with Regulations |

### 1. Technological Assessment Criteria Pairwise Comparisons:


Reliability Security


Reliability Interoperability


Security Interoperability

## 2. Organisational Assessment Criteria Pairwise Comparisons:


SLA Requirements Migration Plans


SLA Requirements Compliance with regulations


Compliance with regulations Migration Plans

Appendix G

# University-A Case Study Report

## Cloud Migration Readiness Result

Prepared for University B

2/20/2017

# Report Outline

After consolidating the results from the instrument, the readiness score for your organisation is illustrated in this report.

The instrument measured the readiness of your university via a set of Readiness Assessment Criteria (RACs) under two dimensions given below:

1. **Technological Assessment Criteria**
    a. Reliability
    b. Security
    c. Interoperability
2. **Organisational Assessment Criteria**
    a. SLA Requirements
    b. Migration Plans
    c. Compliance with Regulations

In this report, the evaluation of each of the RACs will be presented in a hierarchical, bottom-up fashion. Each of these RACs, in this report will be individuals assessed and then combined under their respective dimension to give a broader, higher-level scope. To give more clarity, each of these RAC criteria will be presented via two different chart types describing the same data. Furthermore, a brief explanation of the results in the charts will also be presented.

## Potential solutions to consider

The table below summarises leading providers of technologies and cloud services for the applications and services you have analysed in this assessment. You may wish to consider these in further investigations of suppliers for future development of IT services for the business.

| Service Name | Technology Provider | Cloud Provider |
|---|---|---|
| IaaS Services | | |
| Enterprise Storage | EMC2,NetApp, IBM, Hitachi | Amazon WS, Google, MS Azure |
| Server Visualisation | VM-ware, MS-Hyper-V | Telco-providers, Rackspace |
| Remote Access/Virtual Desktop | Citrix, MS Remote Desktop | Rackspace, CobWeb, Nasstar |
| PaaS Services | | |
| Database | Oracle, DB2 | Amazon-WS, ORACLE, Rackspace |
| Service Management | BMC Remedy, Autotask | BMC, CA Technologies |
| Enterprise Resource Planning | Oracle, SAP | No Famous Cloud Solution Yet |
| SaaS Services | | |
| Intranet | MS Webserver, Unix/Linux | Google, ISP's, Telco-providers |
| .net Apps | Microsoft | Rackspace |

# Section 1 Infrastructure reliability readiness

This section show the processes relevant to reliability readiness to ensure that the migrated systems or services to the cloud operate their required functions without failure during specified workload time and conditions. In this category, there are 5 processes as shown in radar and bar charts respectively.

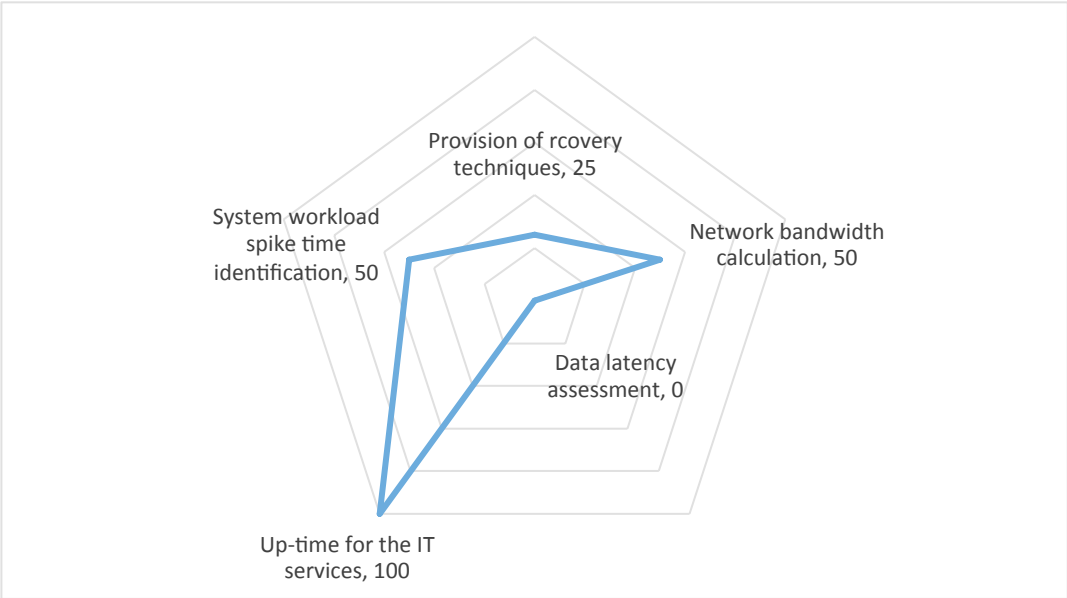



Figure 1: Infrastructure reliability readiness percentage score radar chart

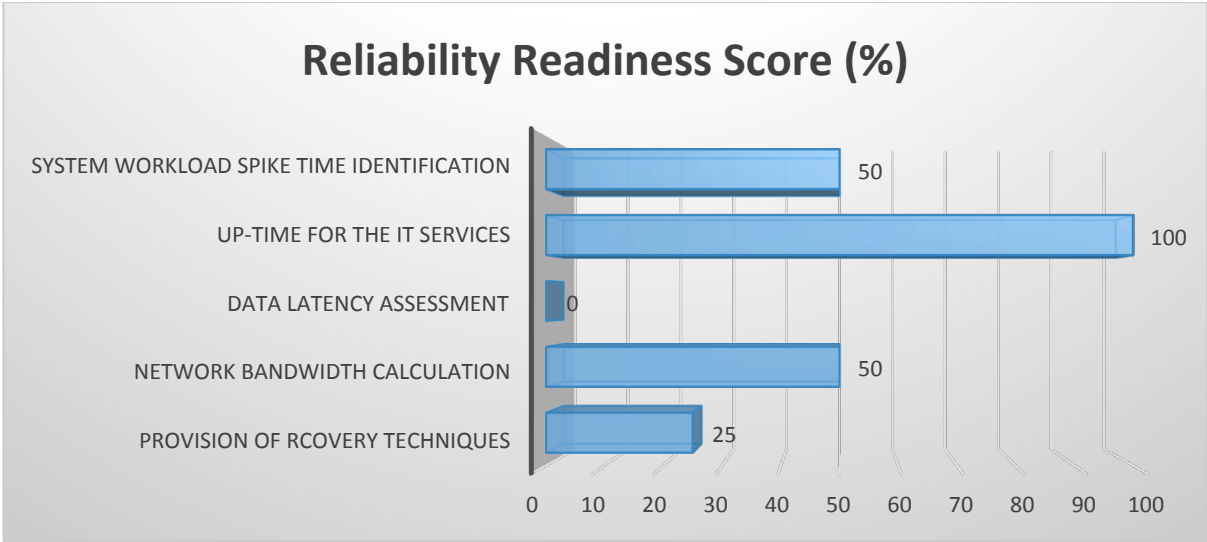



Figure 2: Infrastructure reliability readiness percentage score bar chart

### Excellent Areas (100%):

1. The capability of ensuring high up time all the University IT services. *"Be persistent and no improvement required, that is, the process area is managed quite well and no action needs to be taken before considering the migration process"*

### Adequate Areas (50%):

1. Managing spike time the capability of identifying the system's workload spike times e.g. (Academic semester).
2. Awareness and calculation of the required network bandwidth to host the University's IT services.

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

### Marginal Areas (25%):

1. Provision of disaster recovery technique in the university

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

### Inappropriate Areas (0%):

2. The process of assessing Data Latency for the different IT services

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 1**: In your opinion, do you believe the scores presented in this "Infrastructure Reliability Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

# Section 2 Security Practices Readiness

This section show the processes relevant to the security readiness to ensure that the organisation's migrated hardware, software and data to the cloud is protected against threats or attacks from unauthorised entities, malicious software, and attacks on the hardware and the Internet. In this category, there are 13 processes as shown as radar and bar charts respectively.

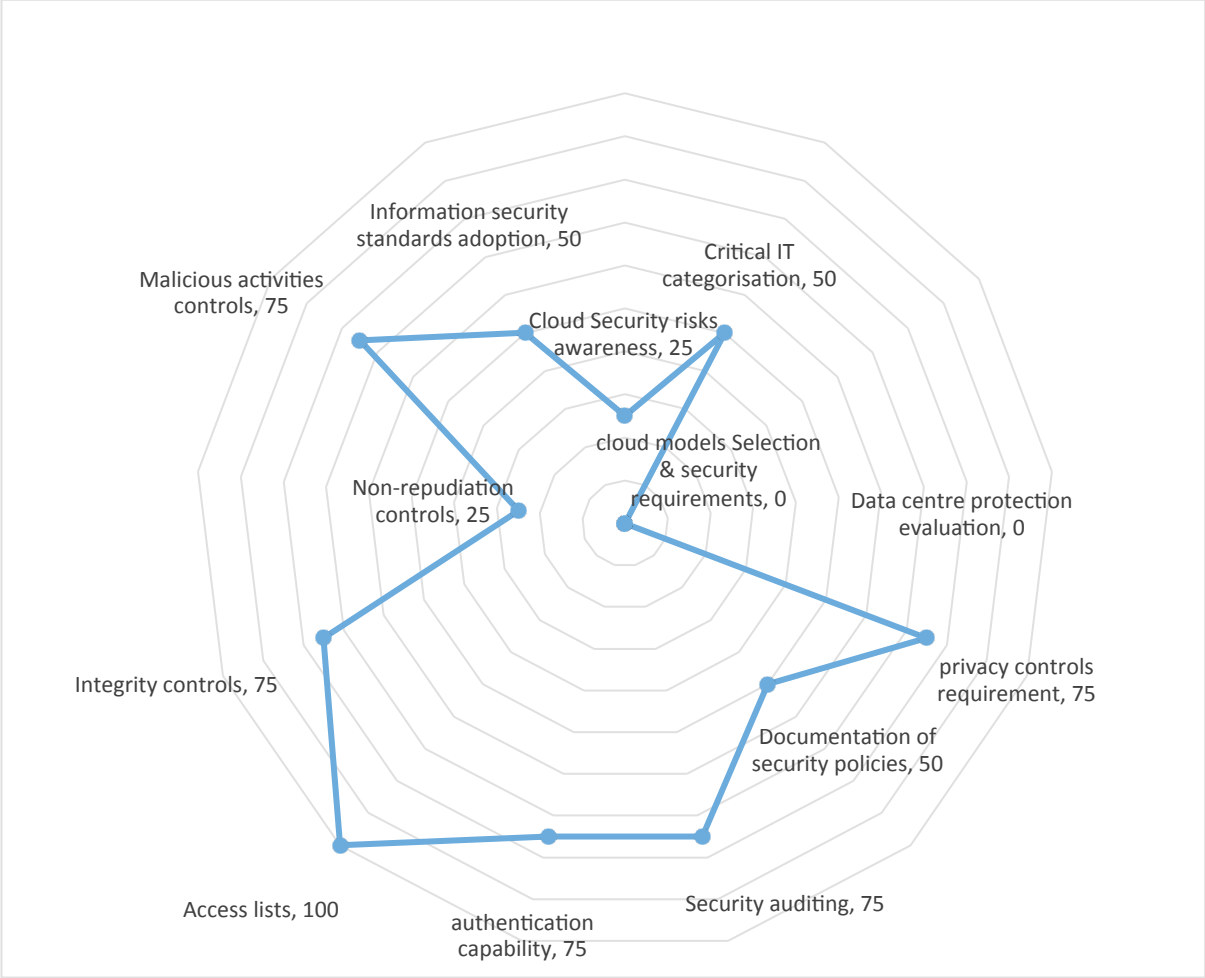



Figure 1: Infrastructure security readiness percentage score radar chart

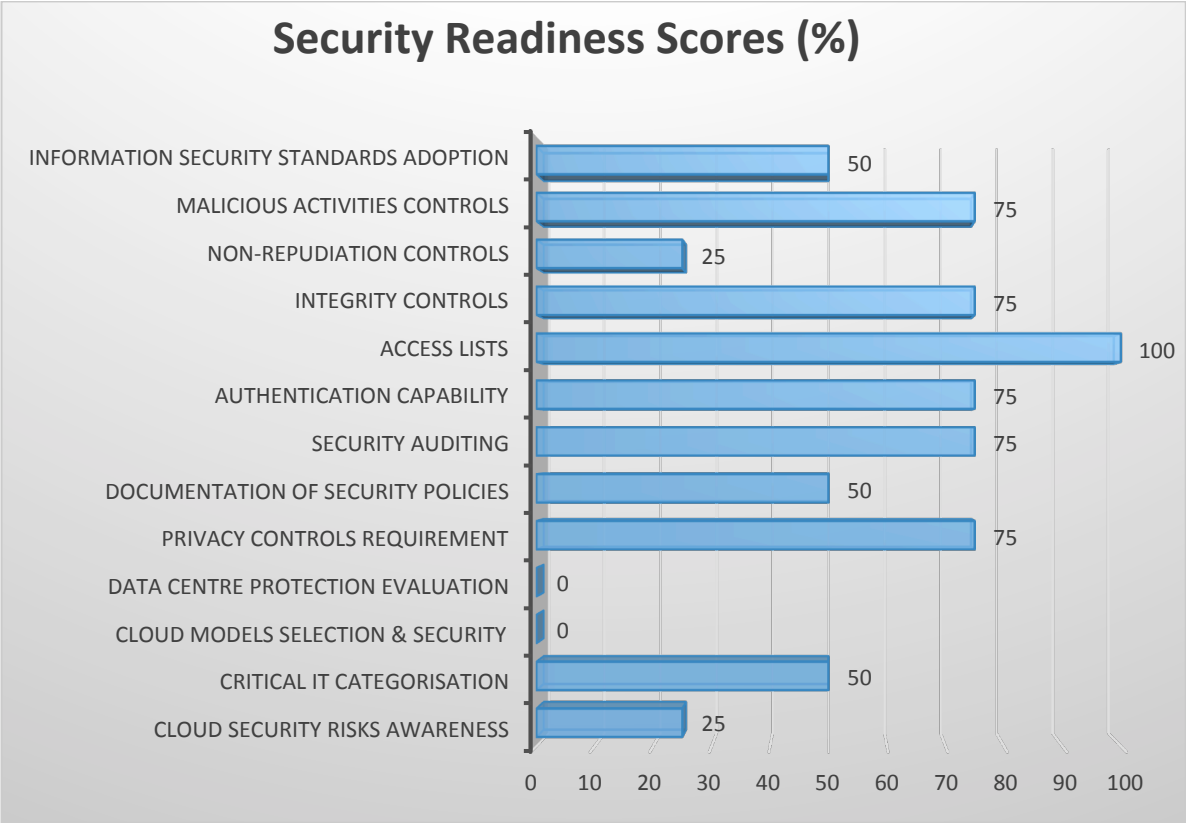



Figure 4: Infrastructure security readiness percentage score bar chart

### Excellent Areas (100%):

1. The capability of managing the stakeholders accounts access lists.

*"Be persistent and no improvement required, that is, the process area is managed quite well and no action needs to be taken before considering the migration process".*

### Good Areas (75%):

1. Capability to detect and control malicious activities.
2. Ensuring integrity by controlling unauthorised entities modifications.
3. Security Auditing.
4. Privacy control technique and requirements.

*"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

### Adequate Areas (50%):

1. Awareness and Adoption of Information security Standards.
2. Documentation of overall IT services security policies.
3. Identifying the critical mission IT systems within the University.

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

### Marginal Areas (25%):

1. Applying non-repudiation controls
2. Awareness of the security risks associated with the migration to the cloud paradigm.

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

### Inappropriate Areas (0%):

1. Evaluating the cloud data centre physical protection level for the provider or within the University.
2. Selecting the diverse cloud models based on security requirements and perspectives

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 2** In your opinion, do you believe the scores presented in this "Security Practices Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

# Section 3 IT Systems' Interoperability Readiness

This section shows the processes relevant to the IT Systems Interoperability readiness. In this category, there are 7 processes as shown as radar and bar charts respectively.

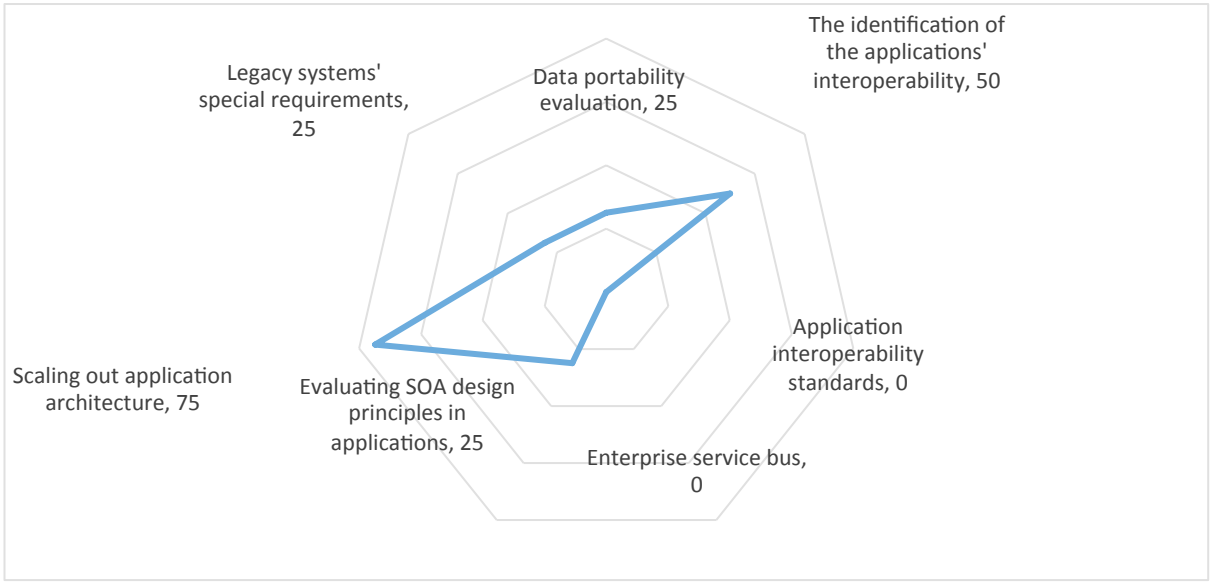



Figure 5: Interoperability readiness percentage score radar chart

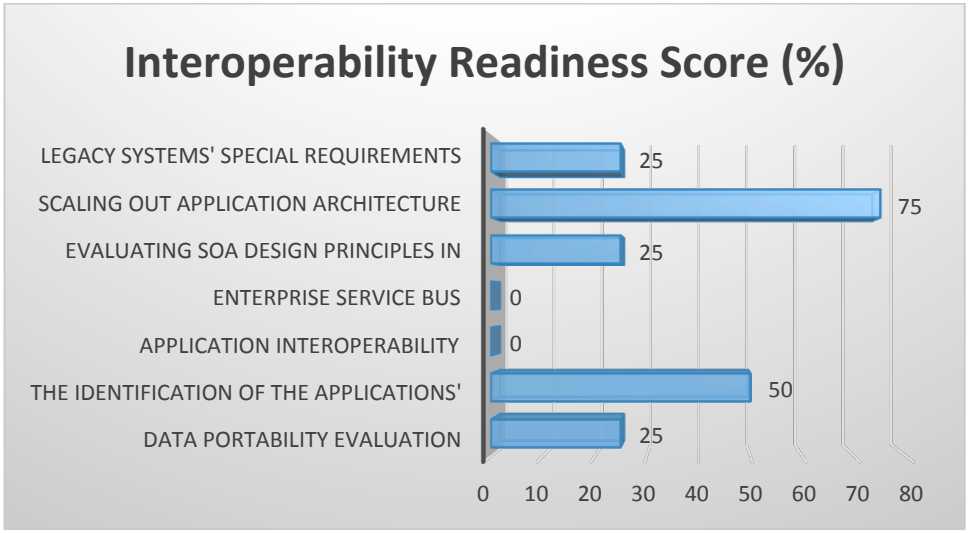



Figure 6: Interoperability security readiness percentage score bar chart

## Good Areas (75%):

1. The capability of the University application to scale out to different servers during spike workloads.

*"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

### Adequate Areas (50%):

1- Awareness and Adoption of Information security Standards.
1- Documentation of overall IT services security policies.
2- Identifying the critical mission IT systems within the University.

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

### Marginal Areas (25%):

1- Identifying legacy systems that require special hardware.
2- Evaluating the University systems that designed based on SOA.
3- Evaluating the portability level of the data in the University system against different cloud computing vendors data format.

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

### Inappropriate Areas (0%):

2. The consideration of implementing Enterprise Service Bus (ESB) to perform interface, protocol and data transformations to address differences between different cloud providers.
3. *The awareness of standards to ensure interoperability of applications on the cloud e.g. (Open virtualisation Format (OVF), Cloud Data Management interface (CDMI)).*

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 3** In your opinion, do you believe the scores presented in this "IT Systems' Interoperability Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

# Section 4 SLA Readiness

This section shows the processes relevant to the SLA readiness. In this category, there are 8 processes as shown in radar and bar charts respectively.

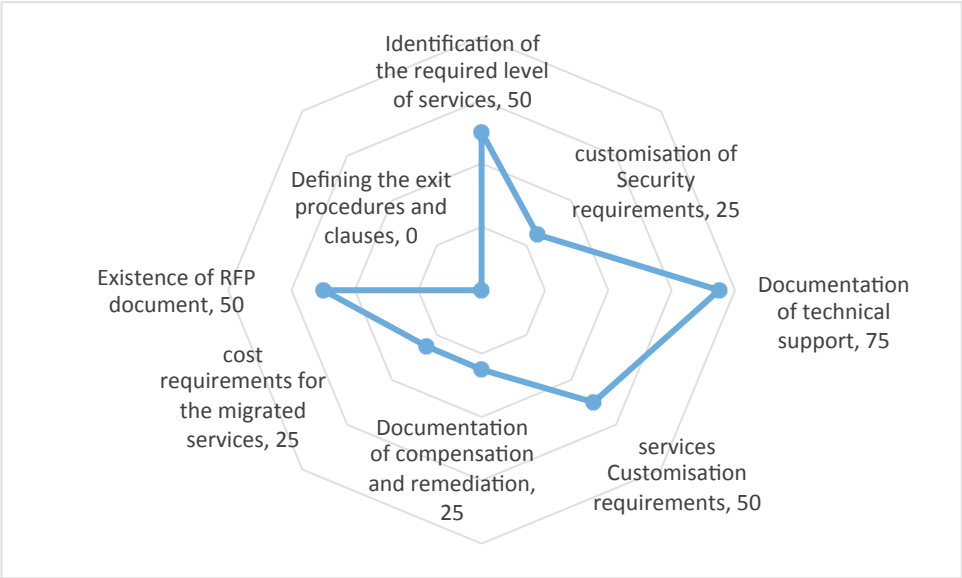



Figure 7: SLA readiness percentage score radar chart

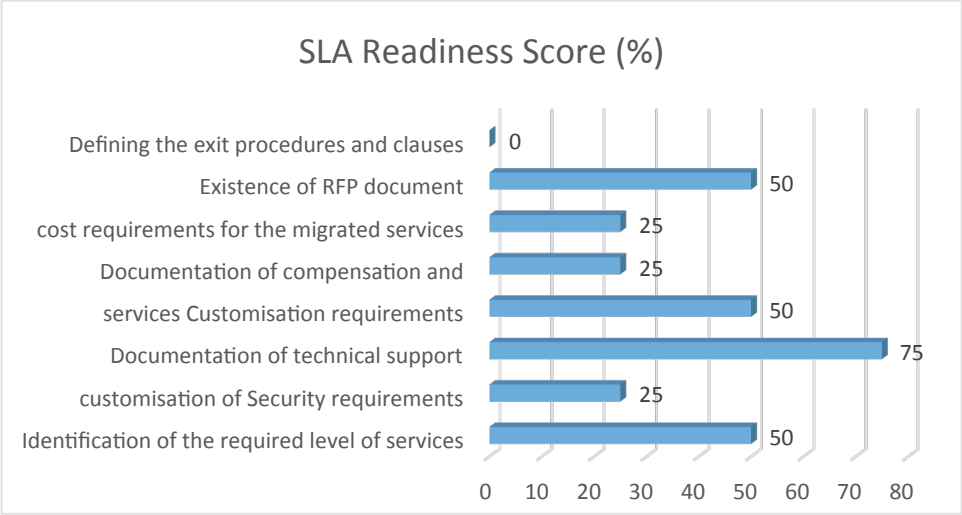



Figure 8: SLA readiness percentage score bar chart

## Good Areas (75%):

1. The documentation of the required cloud technical support from the cloud vendors

   *"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

### Adequate Areas (50%):

1- The preparedness of RFP documents when dealing with different IT suppliers.
2- Set up different customisation requirements for the University IT services that demand so.
3- The identification of the required service level for the migrated services to the cloud e.g. (the expected availability time or locations).

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

### Marginal Areas (25%):

1. The documentation of the required compensation and remediation when fault and failure occur (the penalties required if the guaranteed service level is not met).
2. Defining the satisfied cost requirements for the services migrated e.g. (accepted cost for: one unit of CPU unit, storage, RAM and network for each VM used).
3. The customisation of security requirements for each service migrated to the cloud e.g. (the ability to manage security terms in the cloud SLA).

*"The processes at this level is below average and require substantial improvement before migrating your system to the cloud"*

### Inappropriate Areas (0%):

1. Defining the accepted get-out or exit procedures and clauses in the SLA contract e.g.(the time to move to another cloud provider or how to make sure the data is removed from the previous provider storage).

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 4** In your opinion, do you believe the scores presented in this "SLA Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

# Section 5 Migration Planning Readiness

This section shows the processes relevant to the Migration Planning readiness. In this category, there are 6 processes as shown as radar and bar charts respectively.

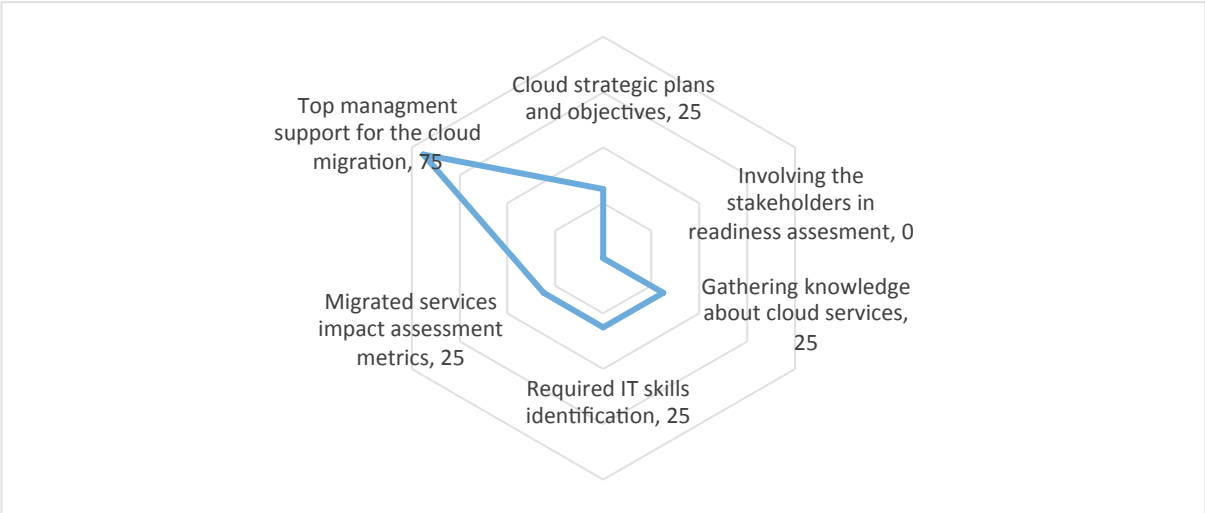



Figure 9: Migration planning readiness percentage score radar chart

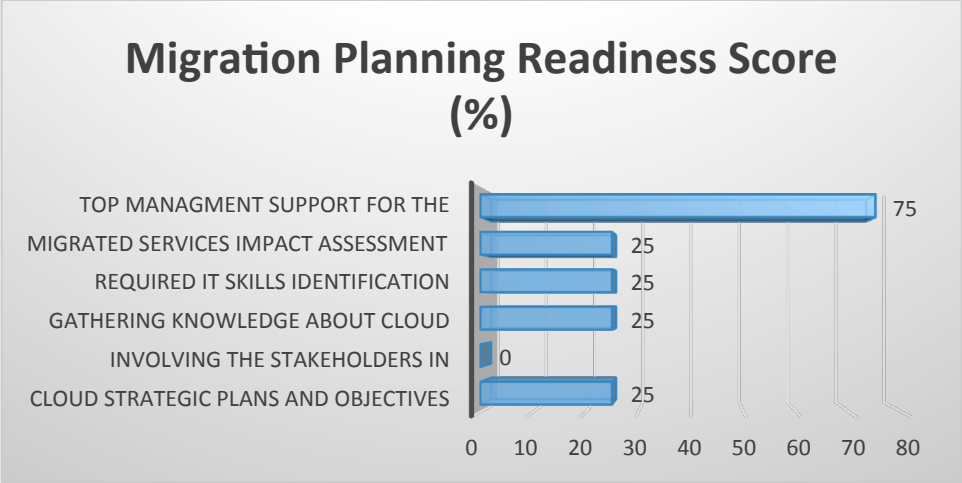



Figure 10: Migration planning readiness percentage score bar chart

### Good Areas (75%):

1. The support of board of directors to cloud migration project and investment in your University e.g. (Managing IS human resources, budget and objectives of cloud usage).

   *"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration*

### Marginal Areas (25%):

1. Establishing the strategic plans and objectives of cloud computing within the IT strategy.

2. Gathering intelligence on cloud services and providers offerings e.g. (structured resources such as successful migrated projects, Experts views, using evaluating tools e.g. SMICLOUD).
3. The identification of the required IT skills to migrate to the cloud against the available skills (Developing required cloud skills Training Programs).
4. Defining the suitable metrics to measure the impact of the migrated services e.g. (assessing cost savings or validate SLA compliance).

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

Inappropriate Areas (0%):

1. Involving the stakeholders (management board, IT staff, employee) in assessing service readiness for the cloud

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 5** In your opinion, do you believe the scores presented in this "Migration Planning Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

# Section 6 Compliance with Regulations Readiness

This section shows the processes relevant to the Compliance with Regulations readiness. In this category, there are 5 processes as shown in radar and bar charts shown in respectively.

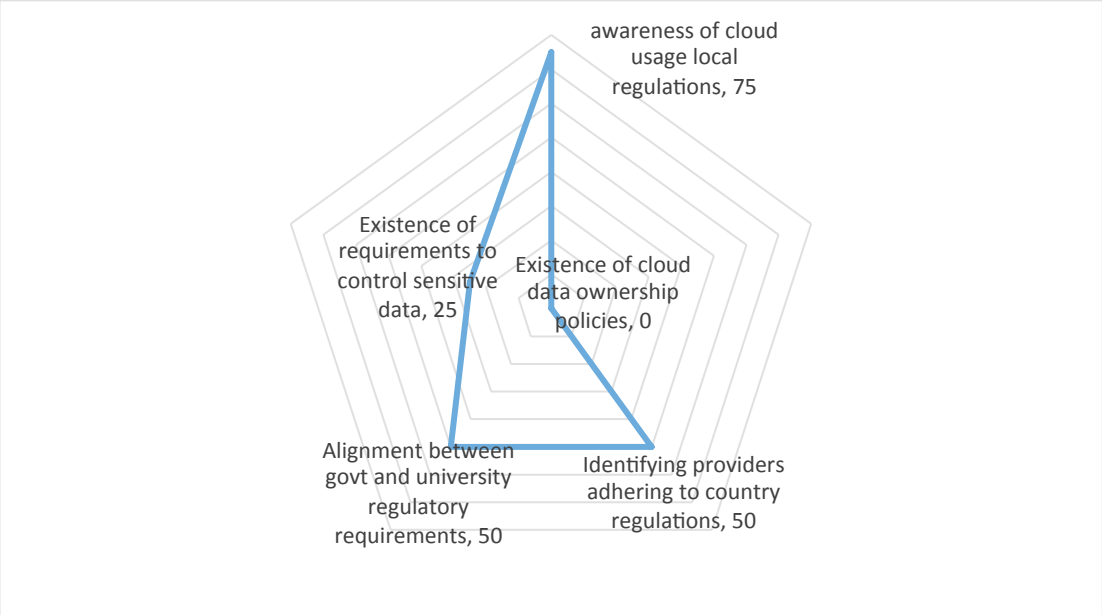



Figure 11: Compliance with Regulations readiness percentage score radar chart

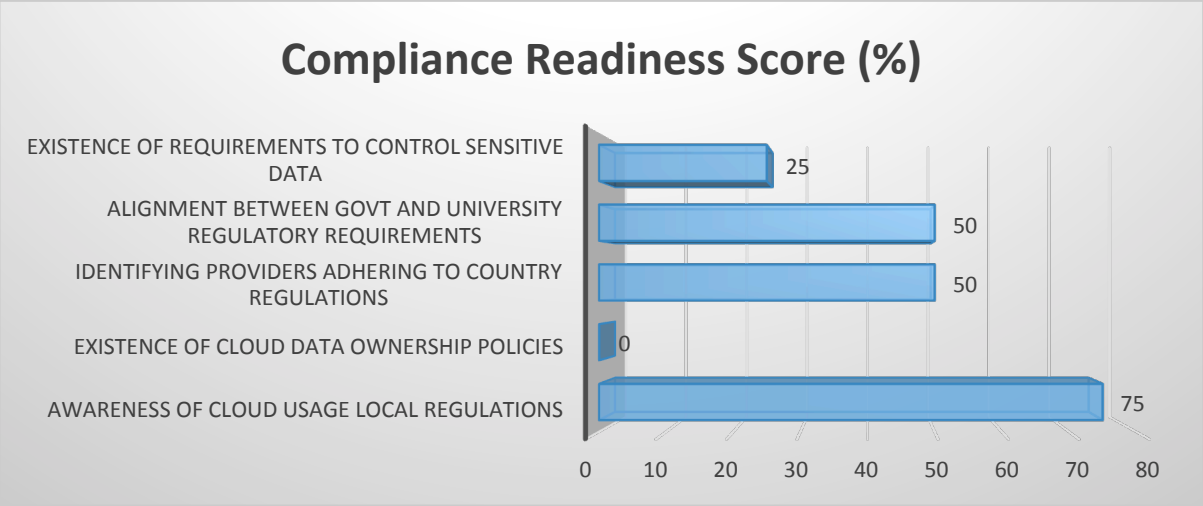



Figure 12: Compliance with Regulations readiness percentage score bar chart

### Good Areas (75%):

1- The identification of the local regulatory requirements to host or outsource to cloud services e.g. (awareness of cloud usage local regulations)

*"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

### Adequate Areas (50%):

1- The alignment between the organisation cloud requirements and the government legal and regulatory requirements including those related to security, privacy and accessibility.
2- Identifying the cloud services and providers that adhere to the country regulations e.g. (licensed vendors).

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

### Marginal Areas (25%):

1. Defining the requirements to control the data over the functionality of the cloud services (how sensitive data will be controlled)

*"The processes at this level is below average and require substantial improvement before migrating your system to the cloud"*

### Inappropriate Areas (0%):

1- Declaration policies to regulate the usage of the data on the cloud (Data ownership policies).

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 6** In your opinion, do you believe the scores presented in this "Compliance with Regulations" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

# Section 7 Overall sections' score

After showing each of these readiness assessment criterion results, this section presents the overall readiness assessment results for the 6 criteria in the instrument. The radar and bar chart-based criteria scores are presented below.

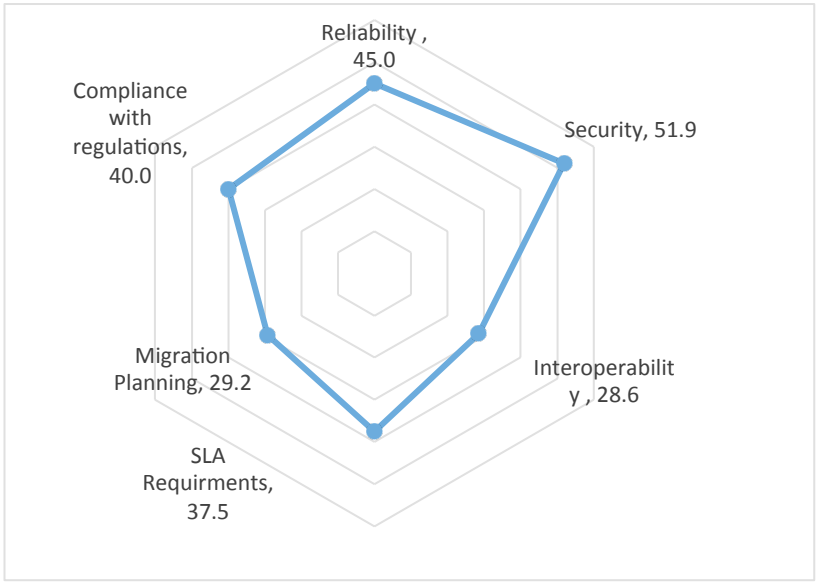



Figure 13: Overall assessment criteria percentage score radar chart

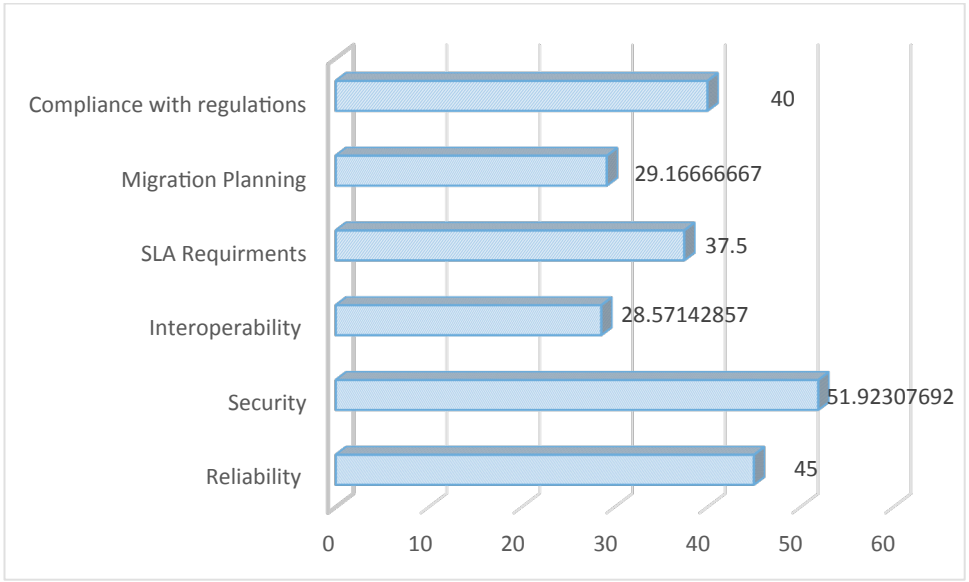



Figure 14: Overall criteria score bar chart

**Based on the readiness assessment of all the assessment criteria, the overall readiness score percentage for your university is:**

**41.34%**

**''Average level of readiness for cloud migration, considerable improvements are needed for successful cloud migration project''**

**Question 7** In your opinion, do you believe the scores presented in this section reflect your actual and overall readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

**Question 8**: To what extent do you believe this instrument is useful in measuring weaknesses as well as strengths of the cloud migration process readiness within the Saudi universities' context?

- Strongly disagree
- Disagree
- Neutral Agree
- Strongly Agree

Appendix H

**University-B Case Study Report**

2/20/2017

# Cloud Migration Readiness Result

## Prepared for University B

Abdulrahman Alharthi

University of Southampton

## Report Outline

After consolidating the results from the instrument, the readiness score for your organisation is illustrated in this report. The instrument measured the readiness of your university via a set of Readiness Assessment Criteria (RCs) under two dimensions given below:

3. **Technological Assessment Criteria**
   a. Reliability
   b. Security
   c. Interoperability
4. **Organisational Assessment Criteria**
   a. SLA Requirements
   b. Migration Plans
   c. Compliance with Regulations

In this report, the evaluation of each of the RACs will be presented in a hierarchical, bottom-up fashion. Each of these RACs, in this report will be individuals assessed and then combined under their respective dimension to give a broader, higher-level scope. To give more clarity, each of these RAC criteria will be presented via two different chart types describing the same data. Furthermore, a brief explanation of the results in the charts will also be presented.

## Potential solutions to consider

The table below summarises leading providers of technologies and cloud services for the applications and services you have analysed in this assessment. You may wish to consider these in further investigations of suppliers for future development of IT services for the business.

| Service Name | Technology Provider | Cloud Provider |
|---|---|---|
| **IaaS Services** | | |
| Enterprise Storage | EMC2,NetApp, IBM, Hitachi | Amazon WS, Google, MS Azure |
| Server Visualisation | VM-ware, MS-Hyper-V | Telco-providers, Rackspace |
| Remote Access/Virtual Desktop | Citrix, MS Remote Desktop | Rackspace, CobWeb, Nasstar |
| **PaaS Services** | | |
| Database | Oracle, DB2 | Amazon-WS, ORACLE, Rackspace |
| Service Management | BMC Remedy, Autotask | BMC, CA Technologies |
| Enterprise Resource Planning | Oracle, SAP | No Famous Cloud Solution Yet |
| **SaaS Services** | | |
| Intranet | MS Webserver, Unix/Linux | Google, ISP's, Telco-providers |
| .net Apps | Microsoft | Rackspace |
| CRM | SAP, Oracle | SalesForce |

## Section 1 Infrastructure reliability readiness score

This section show the processes relevant to reliability readiness to ensure that the migrated systems or services to the cloud operate their required functions without failure during specified workload time and conditions. In this category, there are 5 processes as shown in radar and bar charts respectively.

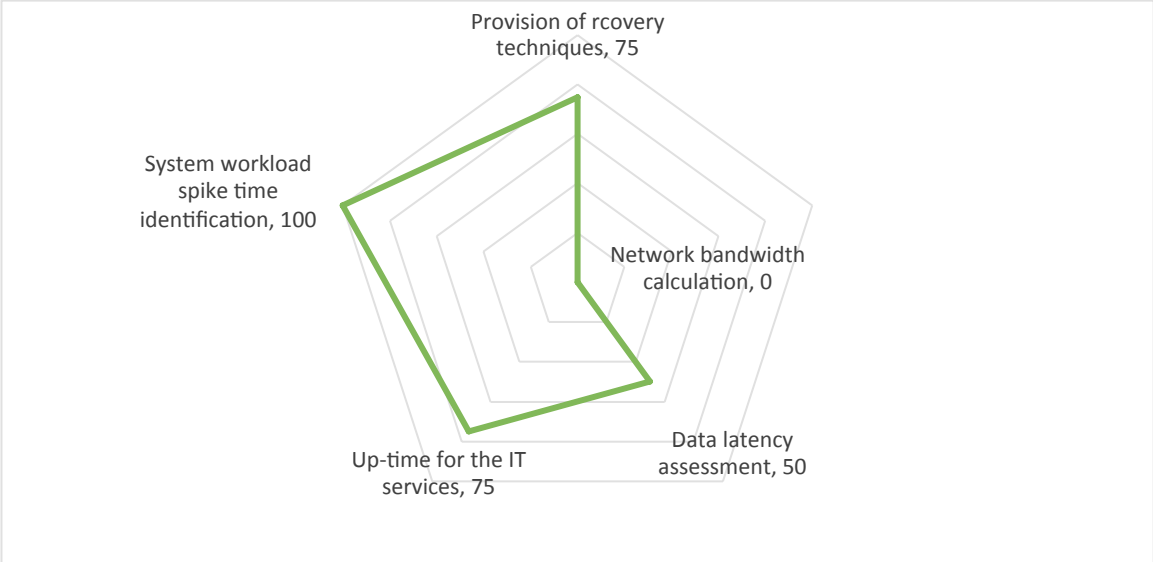



Figure 1: Infrastructure reliability readiness percentage score radar chart

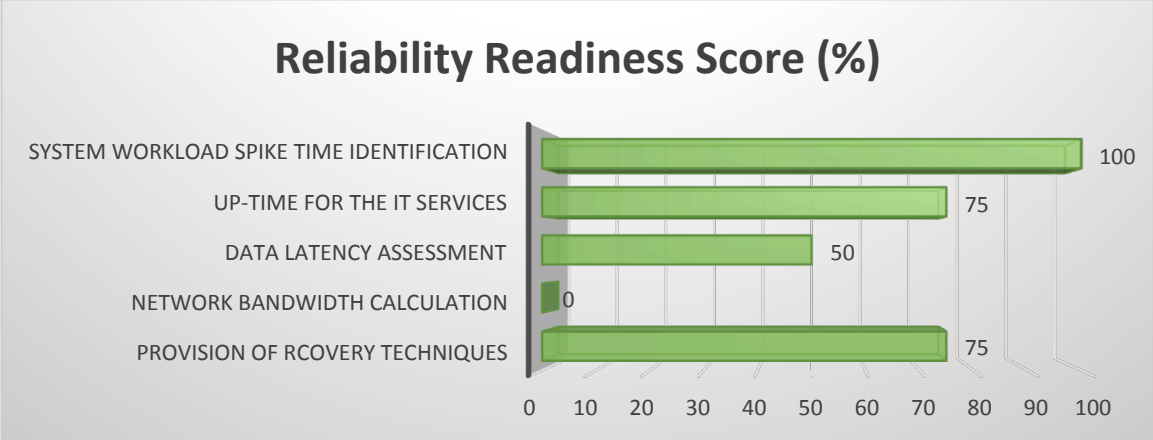



Figure 2: Infrastructure reliability readiness percentage score bar chart

### Excellent Areas (100%):

1- Managing spike time the capability of identifying the system's workload spike times e.g.(Academic semester).

*"Be persistent and no improvement required, that is, the process area is managed quite well and no action needs to be taken before considering the migration process".*

Good Areas (75%):

1- The capability of ensuring high up time all the University IT services.
2- Provision of disaster recovery technique in the university.

*"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

Adequate Areas (50%):

1- The process of assessing Data Latency for the different IT services
2- Awareness and calculation of the required network bandwidth to host the University's IT services.

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

Inappropriate Areas (0%):

1- Awareness and calculation of the required network bandwidth to host the University's IT services.

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 1**: In your opinion, do you believe the scores presented in this "Infrastructure Reliability Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

## Section 2 Security Practices Readiness score

This section show the processes relevant to the security readiness to ensure that the organisation's migrated hardware, software and data to the cloud is protected against threats or attacks from unauthorised entities, malicious software, and attacks on the hardware and the Internet. In this category, there are 13 processes as shown in radar and bar charts respectively.

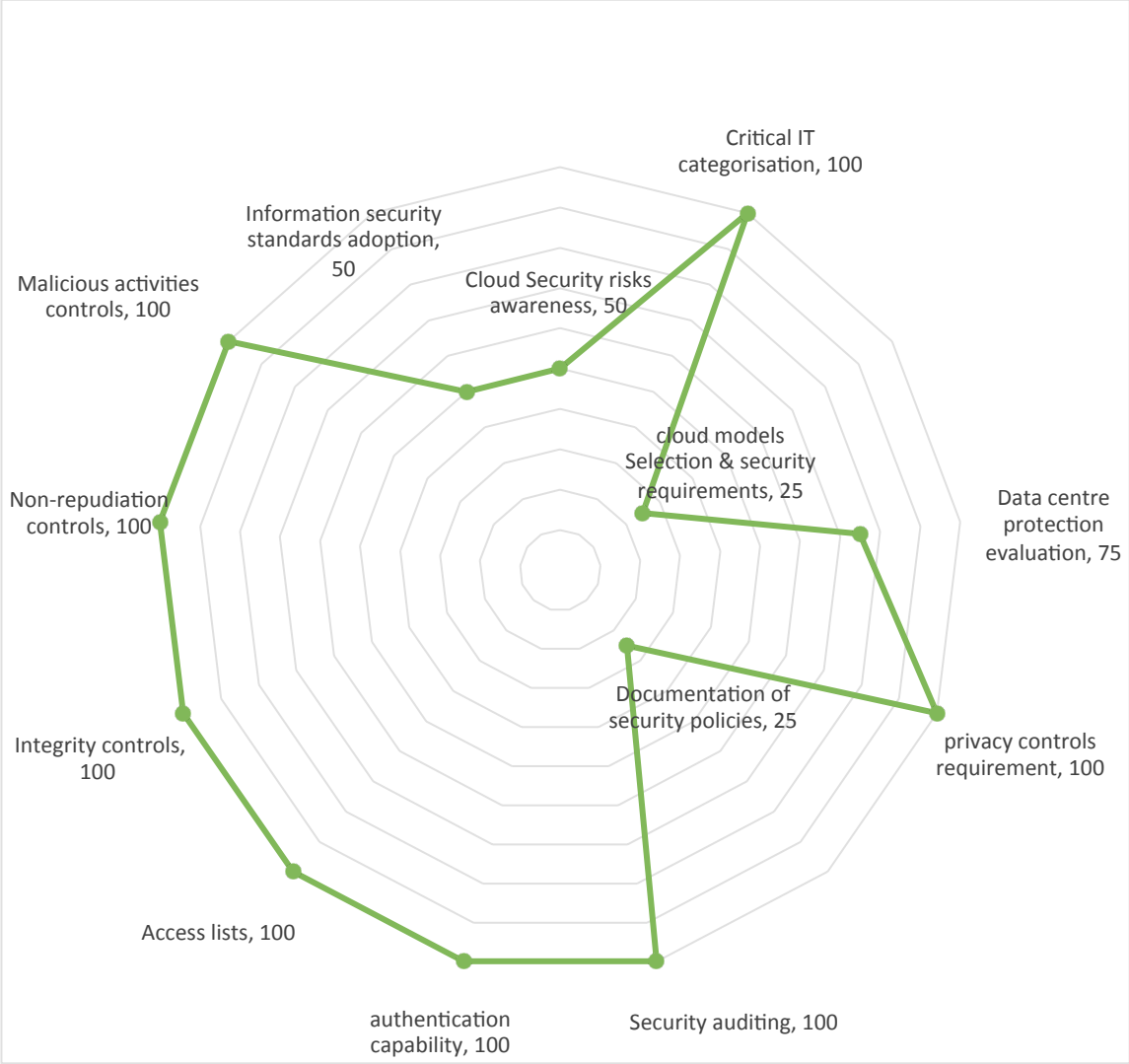



Figure 3: Infrastructure security readiness percentage score radar chart

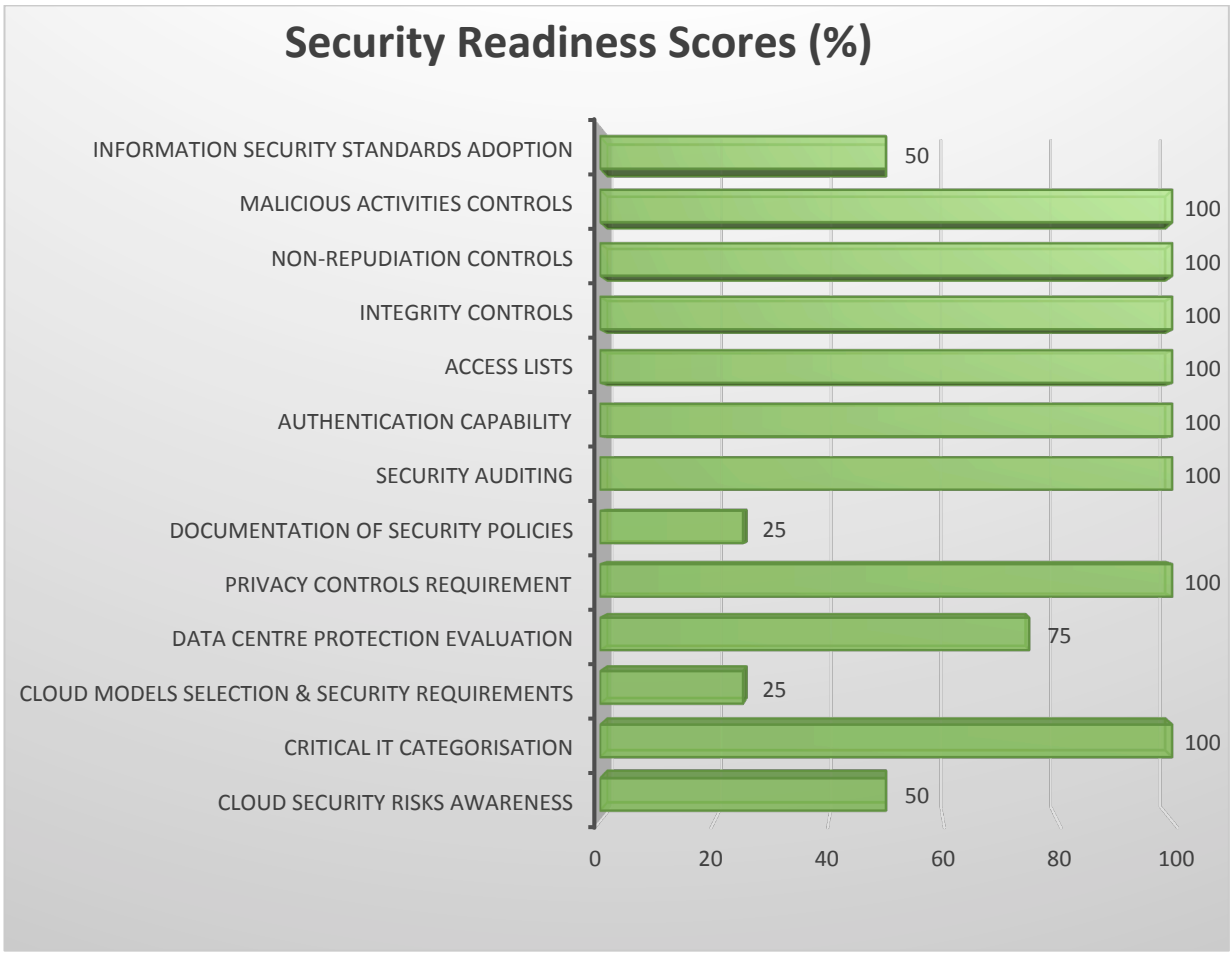



Figure 4: Infrastructure security readiness percentage score bar chart

### Excellent Areas (100%):

1- The capability of managing the stakeholders' accounts access lists.
2- The capability to authenticate the university stakeholders' credentials.
3- Privacy control technique and requirements.
4- Ensuring integrity by controlling unauthorised entities modifications.
5- Capability to detect and control malicious activities.
6- Applying non-repudiation controls.
7- The process of auditing the security devices and techniques.
8- Identifying the critical mission IT systems within the University.

> *"Be persistent and no improvement required, that is, the process area is managed quite well and no action needs to be taken before considering the migration process".*

### Good Areas (75%):

1- Evaluating the cloud data centre physical protection level for the provider or within the University.

*"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

Adequate Areas (50%):

1- Awareness of the security risks associated with the migration to the cloud paradigm.
2- Awareness and Adoption of Information security Standards.

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

Marginal Areas (25%):

1- Selecting the diverse cloud models based on security requirements and perspectives.
2- Documentation of overall IT services security policies.

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

**Question 2** In your opinion, do you believe the scores presented in this "Security Practices Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

## Section 3 IT Systems Interoperability Readiness score

This section shows the processes relevant to the IT Systems' Interoperability readiness. In this category, there are 7 processes as shown as radar and bar charts shown in Figure  and Figure  respectively.

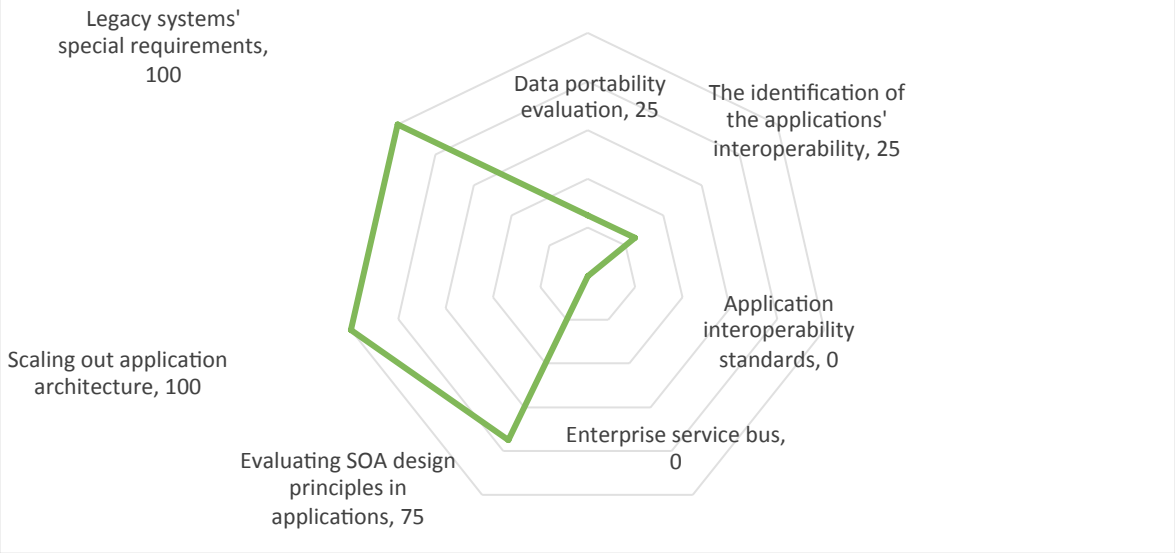



Figure 5: Interoperability readiness percentage score radar chart

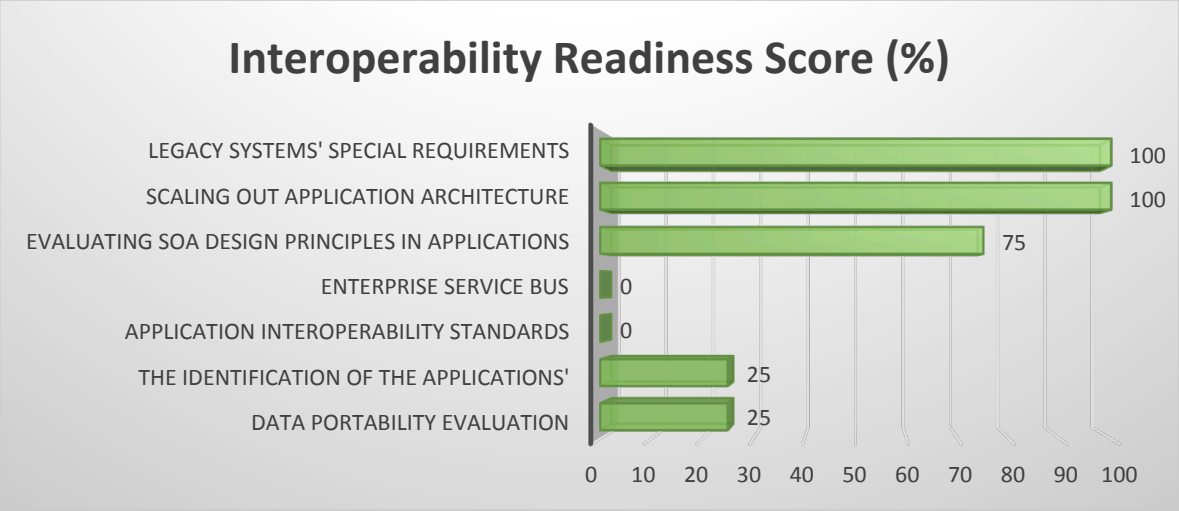



Figure 6: Interoperability security readiness percentage score bar chart

### Excellent Areas (100%):

1- The capability of the University application to scale out to different servers during spike workloads.
2- Identifying legacy systems that require special hardware.

*"Be persistent and no improvement required, that is, the process area is managed quite well and no action needs to be taken before considering the migration process".*

### Good Areas (75%):

1- Evaluating the University systems that designed based on SOA.

*"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

Marginal Areas (25%):

1- Evaluating the portability level of the data in the University system against different cloud computing vendors data format.
2- The identification of the required level of interoperability for the migrated applications based on the service models ( Low level SaaS, Medium level PaaS and high level IaaS)

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

Inappropriate Areas (0%):

1- The awareness of standards to ensure interoperability of applications on the cloud e.g. (Open virtualisation Format (OVF), Cloud Data Management interface (CDMI).
2- The consideration of implementing Enterprise Service Bus (ESB) to perform interface, protocol and data transformations to address differences between different cloud providers.

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 3** In your opinion, do you believe the scores presented in this "IT Systems' Interoperability Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

## Section 4 SLA Readiness score

This section shows the processes relevant to the SLA readiness. In this category, there are 8 processes as shown in radar and bar charts respectively.

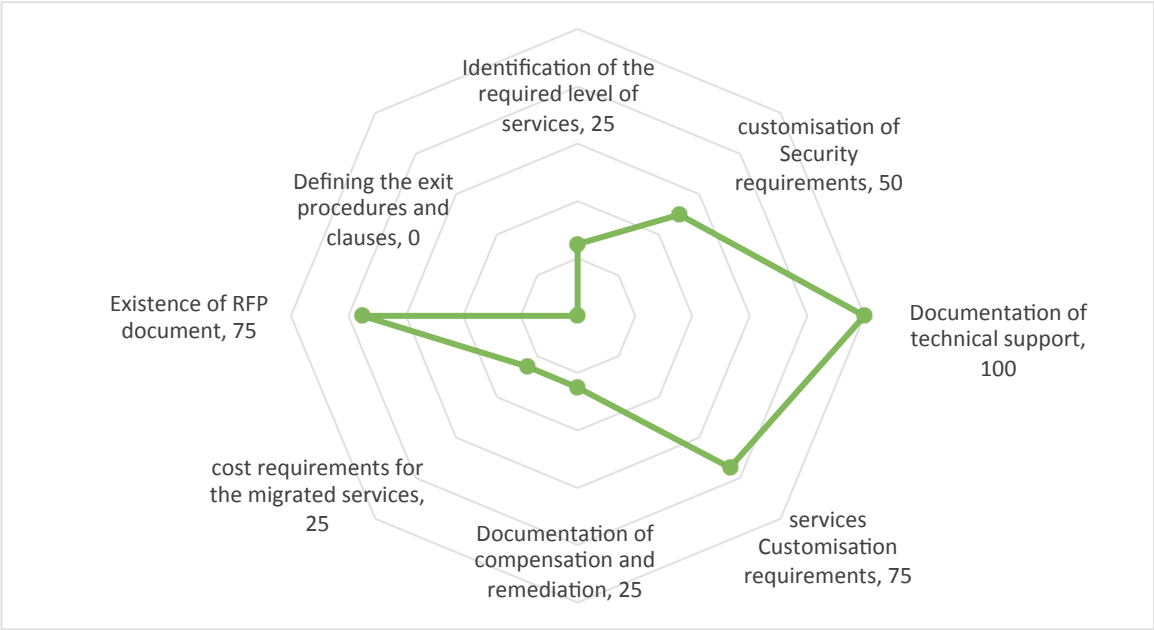



Figure 7: SLA readiness percentage score radar chart

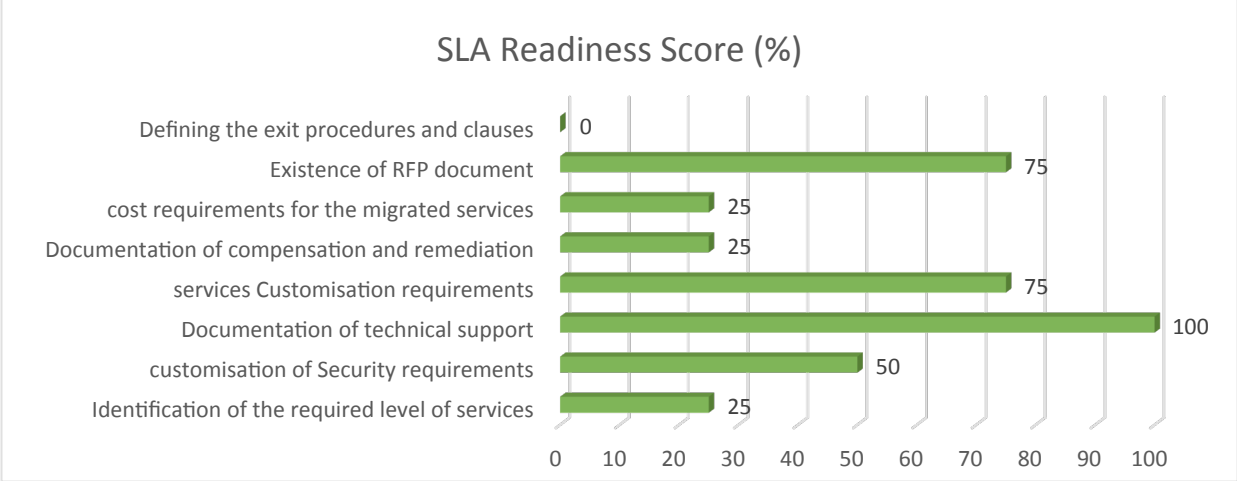



Figure 8: SLA readiness percentage score bar chart

### Excellent Areas (100%):

1- The documentation of the required cloud technical support from the cloud vendors

*"Be persistent and no improvement required, that is, the process area is managed quite well and no action needs to be taken before considering the migration process".*

### Good Areas (75%):

1- The preparedness of RFP documents when dealing with different IT suppliers.
2- Set up different customisation requirements for the University IT services that demand so.

*"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

Adequate Areas (50%):

4- The customisation of security requirements for each service migrated to the cloud e.g. (the ability to manage security terms in the cloud SLA).

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

Marginal Areas (25%):

1- The identification of the required service level for the migrated services to the cloud e.g. (the expected availability time or locations).
2- The documentation of the required compensation and remediation when fault and failure occur (the penalties required if the guaranteed service level is not met).
3- Defining the satisfied cost requirements for the services migrated e.g. (accepted cost for: one unit of CPU unit, storage, RAM and network for each VM used).

*"The processes at this level is below average and require substantial improvement before migrating your system to the cloud"*

Inappropriate Areas (0%):

1- Defining the accepted get-out or exit procedures and clauses in the SLA contract e.g. (the time to move to another cloud provider or how to make sure the data is removed from the previous provider storage).

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 4** In your opinion, do you believe the scores presented in this "SLA Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

## Section 5 Migration Planning Readiness score

This section shows the processes relevant to the Migration Planning readiness. In this category, there are 6 processes as shown in radar and bar charts respectively.

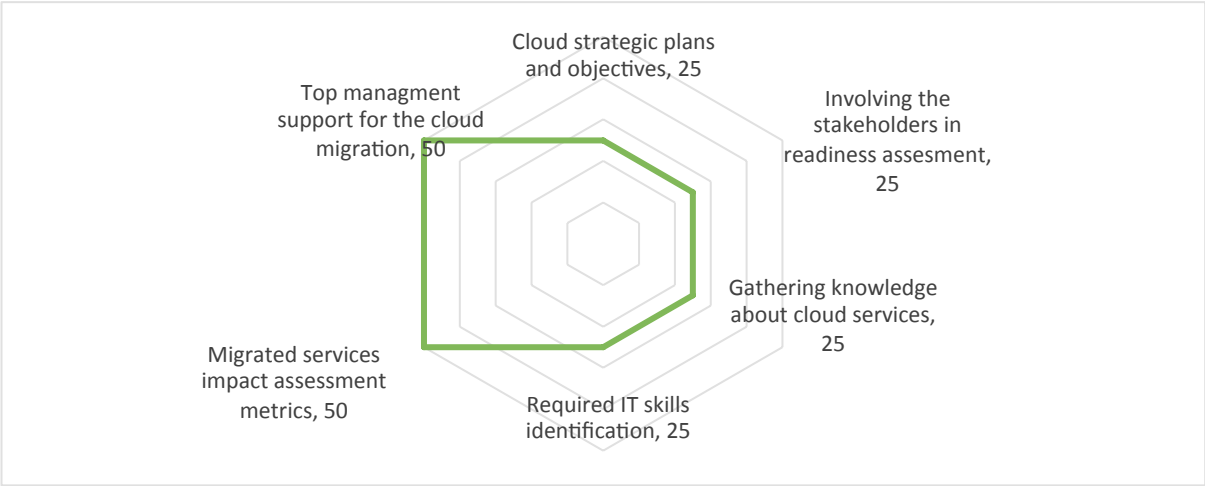



Figure 9: Migration planning readiness percentage score radar chart

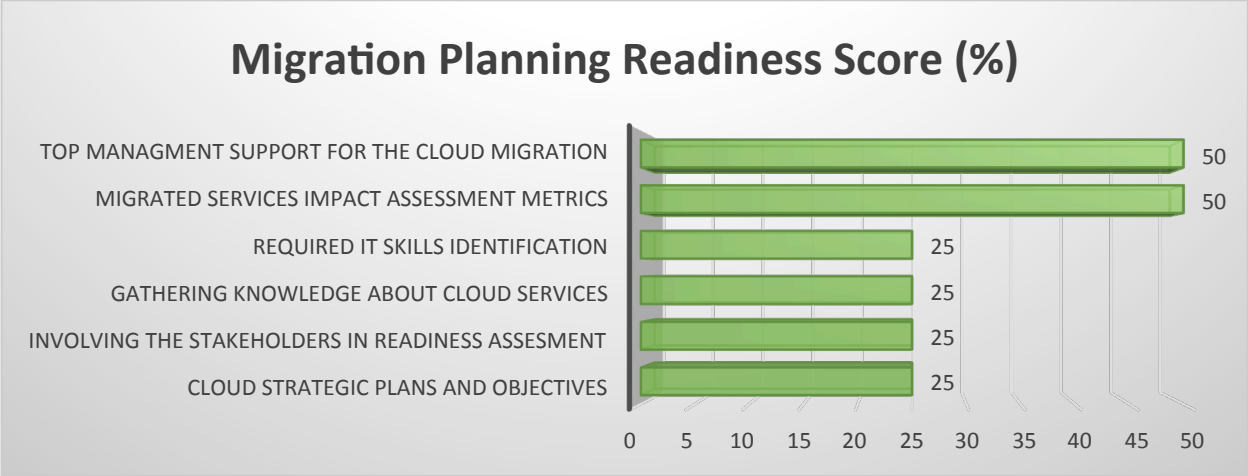



Figure 10: Migration planning readiness percentage score bar chart

### Adequate Areas (50%):

2- Defining the suitable metrics to measure the impact of the migrated services e.g. (assessing cost savings or validate SLA compliance).

3- The support of board of directors to cloud migration project and investment in your University e.g. (Managing IS human resources, budget and objectives of cloud usage).

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

Marginal Areas (25%):

1- Establishing the strategic plans and objectives of cloud computing within the IT strategy.
2- Gathering intelligence on cloud services and providers offerings e.g. (structured resources such as successful migrated projects, Experts views, using evaluating tools e.g. SMICLOUD).
3- Involving the stakeholders (management board, IT staff, and employee) in assessing service readiness for the cloud.
4- The identification of the required IT skills to migrate to the cloud against the available skills (Developing required cloud skills Training Programs).

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

**Question 5** In your opinion, do you believe the scores presented in this "Migration Planning Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

## Section 6 Compliance with Regulations Readiness score

This section shows the processes relevant to the Compliance with Regulations readiness. In this category, there are 5 processes as shown as radar and bar charts shown in Figure 11 and 12 respectively.

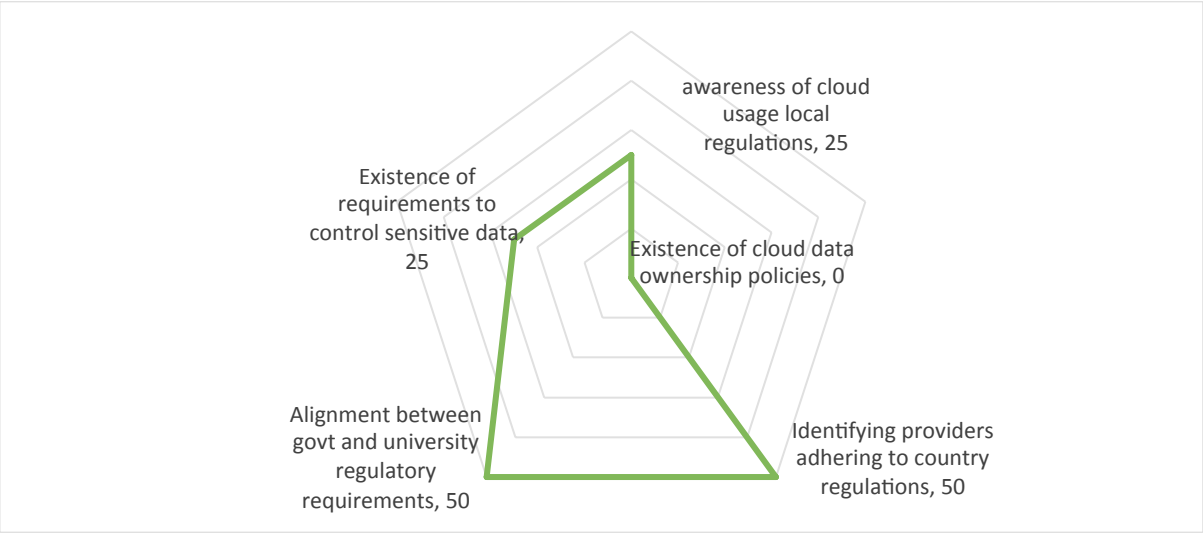



Figure 11: Compliance with Regulations readiness percentage score radar chart

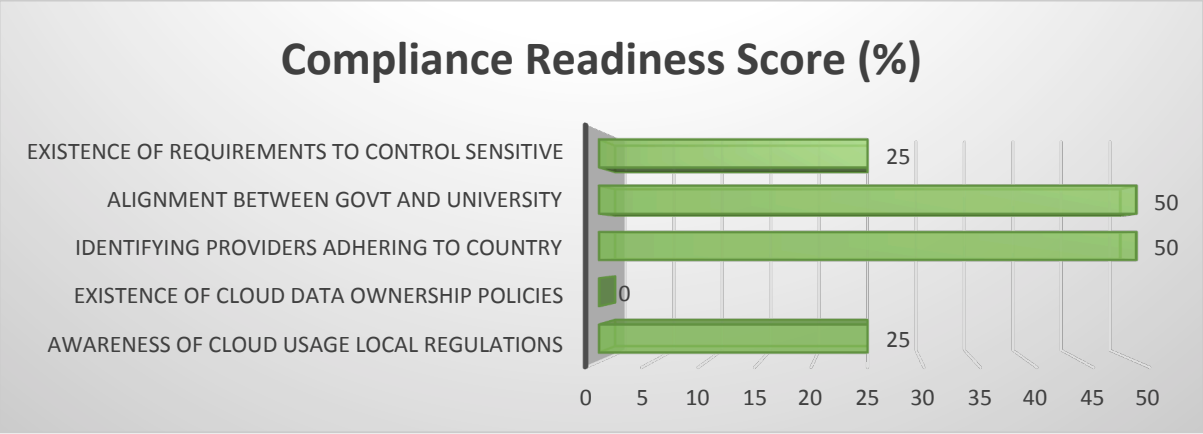



Figure 12: Compliance with Regulations readiness percentage score bar chart

### Adequate Areas (50%):

1- The alignment between the organisation cloud requirements and the government legal and regulatory requirements including those related to security, privacy and accessibility.

2- Identifying the cloud services and providers that adhere to the country regulations e.g. (licensed vendors).

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

Marginal Areas (25%):

1- Defining the requirements to control the data over the functionality of the cloud services (how sensitive data will be controlled).
2- The identification of the local regulatory requirements to host or outsource to cloud services e.g. (awareness of cloud usage local regulations).

*"The processes at this level is below average and require substantial improvement before migrating your system to the cloud"*

Inappropriate Areas (0%):

1- Declaration policies to regulate the usage of the data on the cloud (Data ownership policies).

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 6** In your opinion, do you believe the scores presented in this "Compliance with Regulations" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

## Section 7 Overall sections' score

After showing each of the readiness assessment criterion results, this section presents the overall readiness assessment results for the 6 criteria in the instrument. The radar and bar chart-based criteria scores are presented in the following figures.

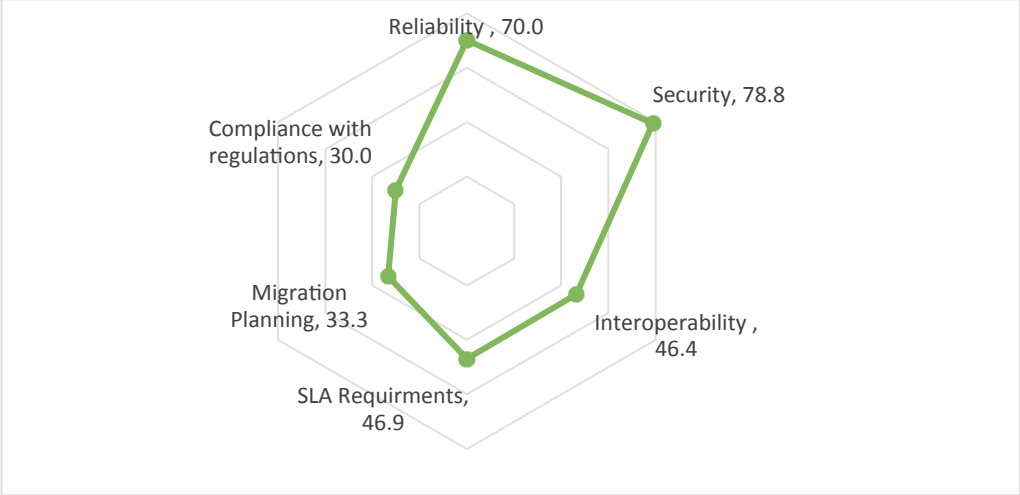



Figure 13: Overall assessment criteria percentage score radar chart

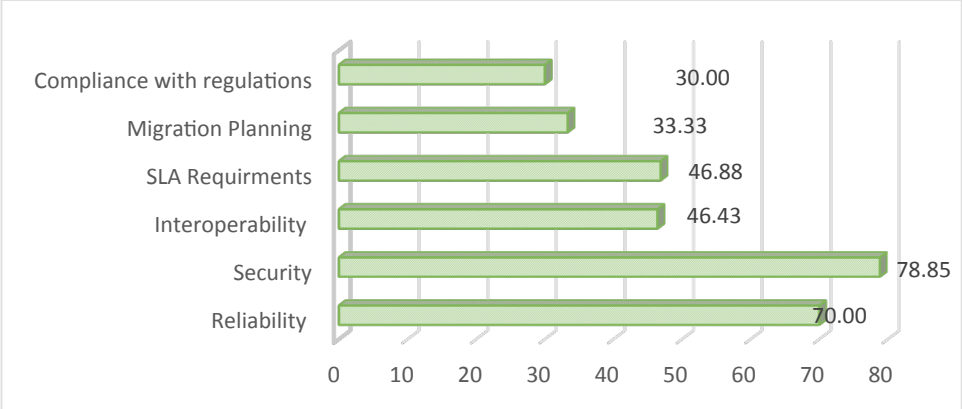



Figure 14: Overall criteria score bar chart

**Based on the readiness assessment of all the assessment criteria, the overall readiness score percentage for your university is:**

**The Technological Readiness is 76.67%**

**The organisational Readiness is 47.87%**

**Overall Readiness Score: 62.7%**

**"Solid level of readiness for cloud migration, Minor improvements are needed to bring the readiness score to the successful readiness level for cloud migration"**

**Question 7** In your opinion, do you believe the scores presented in this section reflect your actual and overall readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

**Question 8**: To what extent do you believe this instrument is useful in measuring weaknesses as well as strengths of the cloud migration process readiness within the Saudi universities' context?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Appendix I

**University-C Case Study Report**

2/20/2017

# Cloud Migration Readiness Result

Prepared for University B

# Report Outline

After consolidating the results from the instrument, the readiness score for your organisation is illustrated in this report.

The instrument measured the readiness of your university via a set of Readiness Assessment Criteria (RACs) under two dimensions given below:

5. **Technological Assessment Criteria**
   a. Reliability
   b. Security
   c. Interoperability
6. **Organisational Assessment Criteria**
   a. SLA Requirements
   b. Migration Plans
   c. Compliance with Regulations

In this report, the evaluation of each of the RACs will be presented in a hierarchical, bottom-up fashion. Each of these RACs, in this report will be individuals assessed and then combined under their respective dimension to give a broader, higher-level scope. To give more clarity, each of these RAC criteria will be presented via two different chart types describing the same data. Furthermore, a brief explanation of the results in the charts will also be presented.

## Potential solutions to consider

The table below summarises leading providers of technologies and cloud services for the applications and services you have analysed in this assessment. You may wish to consider these in further investigations of suppliers for future development of IT services for the business.

| Service Name | Technology Provider | Cloud Provider |
|---|---|---|
| IaaS Services | | |
| Enterprise Storage | EMC2,NetApp, IBM, Hitachi | Amazon WS, Google, MS Azure |
| Server Visualisation | VM-ware, MS-Hyper-V | Telco-providers, Rackspace |
| Remote Access/Virtual Desktop | Citrix, MS Remote Desktop | Rackspace, CobWeb, Nasstar |
| PaaS Services | | |
| Database | Oracle, DB2 | Amazon-WS, ORACLE, Rackspace |
| Service Management | BMC Remedy, Autotask | BMC, CA Technologies |
| Enterprise Resource Planning | Oracle, SAP | No Famous Cloud Solution Yet |
| SaaS Services | | |
| Intranet | MS Webserver, Unix/Linux | Google, ISP's, Telco-providers |
| .net Apps | Microsoft | Rackspace |

# Section 1 Infrastructure reliability readiness

This section show the processes relevant to reliability readiness to ensure that the migrated systems or services to the cloud operate their required functions without failure during specified workload time and conditions. In this category, there are 5 processes as shown as radar and bar charts shown in Figure  and Figure respectively.

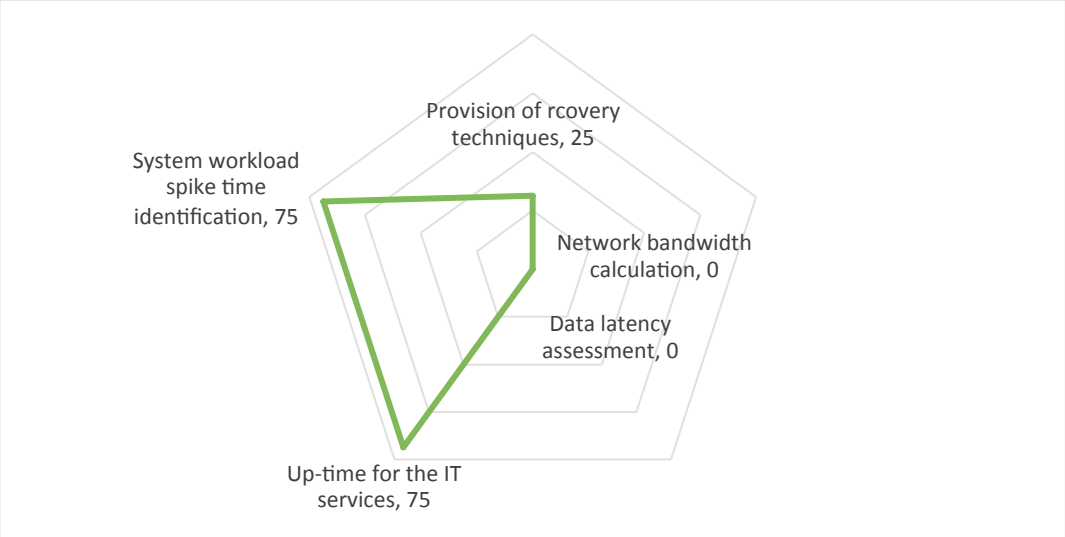



Figure 1: Infrastructure reliability readiness percentage score radar chart

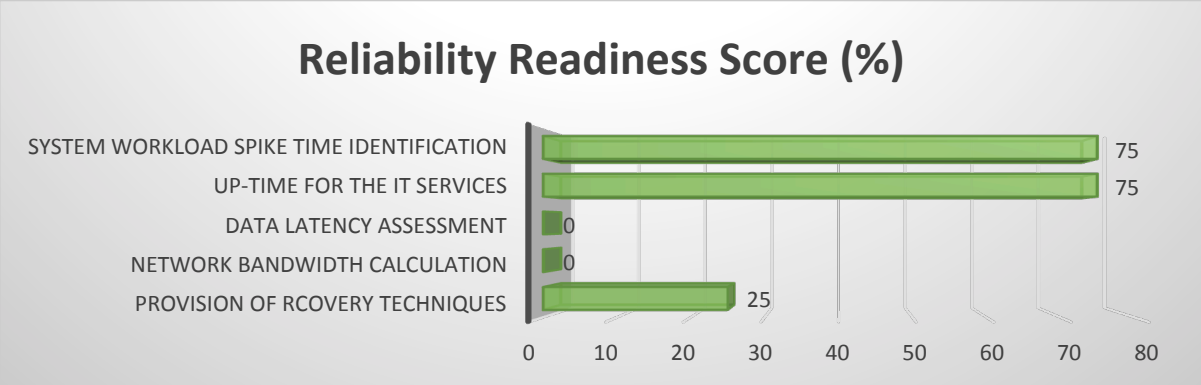



Figure 2: Infrastructure reliability readiness percentage score bar chart

### Excellent Areas (75%):

1- The capability of ensuring high up time all the University IT services.
2- Managing spike time the capability of identifying the system's workload spike times e.g. (Academic semester).

> *"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

Marginal Areas (25%):

1- Provision of disaster recovery technique in the university

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

Inappropriate Areas (0%):

1- The process of assessing Data Latency for the different IT services
2- Awareness and calculation of the required network bandwidth to host the University's IT services.

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 1**: In your opinion, do you believe the scores presented in this "Infrastructure Reliability Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

## Section 2 Security Practices Readiness

This section show the processes relevant to the security readiness to ensure that the organisation□s migrated hardware, software and data to the cloud is protected against threats or attacks from unauthorised entities, malicious software, and attacks on the hardware and the Internet. In this category, there are 13 processes as shown as radar and bar charts shown in Figure  and Figure  respectively.

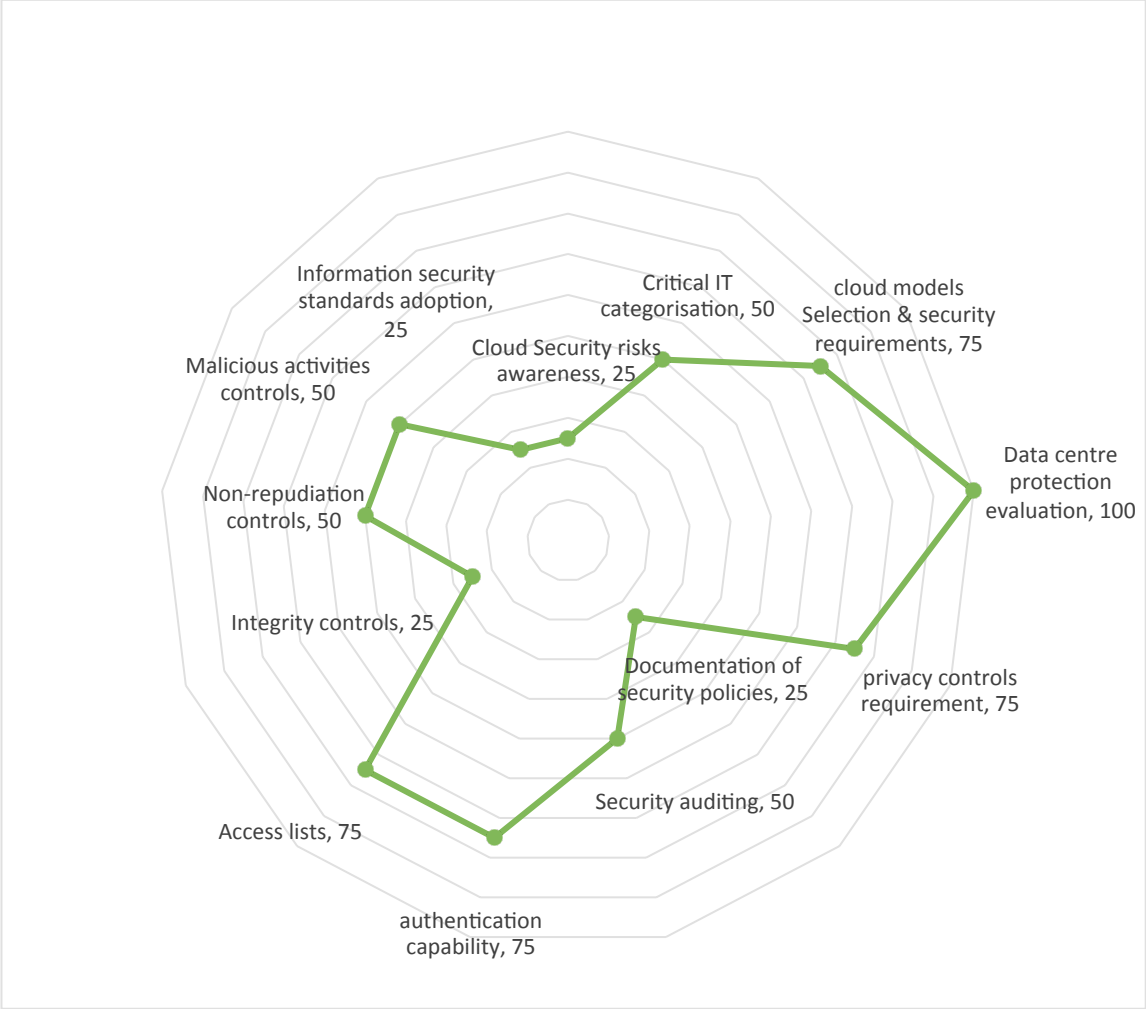



Figure 3: Infrastructure security readiness percentage score radar chart

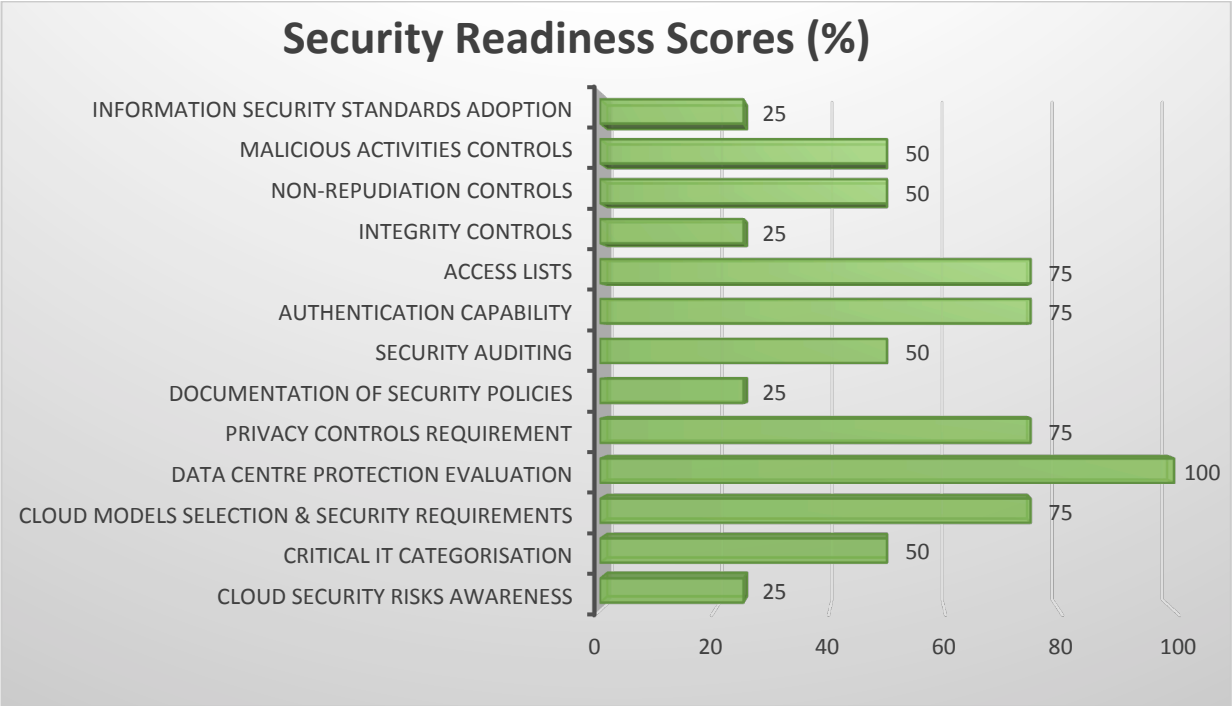



Figure 4: Infrastructure security readiness percentage score bar chart

### Excellent Areas (100%):

1- Evaluating the cloud data centre physical protection level for the provider or within the University.

*"Be persistent and no improvement required, that is, the process area is managed quite well and no action needs to be taken before considering the migration process".*

### Good Areas (75%):

1- The capability of managing the stakeholders accounts access lists.
2- Selecting the diverse cloud models based on security requirements and perspectives.
3- The capability to authenticate the university stakeholders credentials.
4- Privacy control technique and requirements.

*"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

### Adequate Areas (50%):

1- Capability to detect and control malicious activities.
2- Applying non-repudiation controls.
3- The process of auditing the security devices and techniques.
4- Identifying the critical mission IT systems within the University.

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

### Marginal Areas (25%):

1- Awareness of the security risks associated with the migration to the cloud paradigm.
2- Awareness and Adoption of Information security Standards.
3- Documentation of overall IT services security policies.
4- Ensuring integrity by controlling unauthorised entities modifications.

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

**Question 2** In your opinion, do you believe the scores presented in this "Security Practices Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

## Section 3 IT Systems' Interoperability Readiness

This section shows the processes relevant to the IT Systems Interoperability readiness. In this category, there are 7 processes as shown as radar and bar charts shown in Figure and Figure respectively.

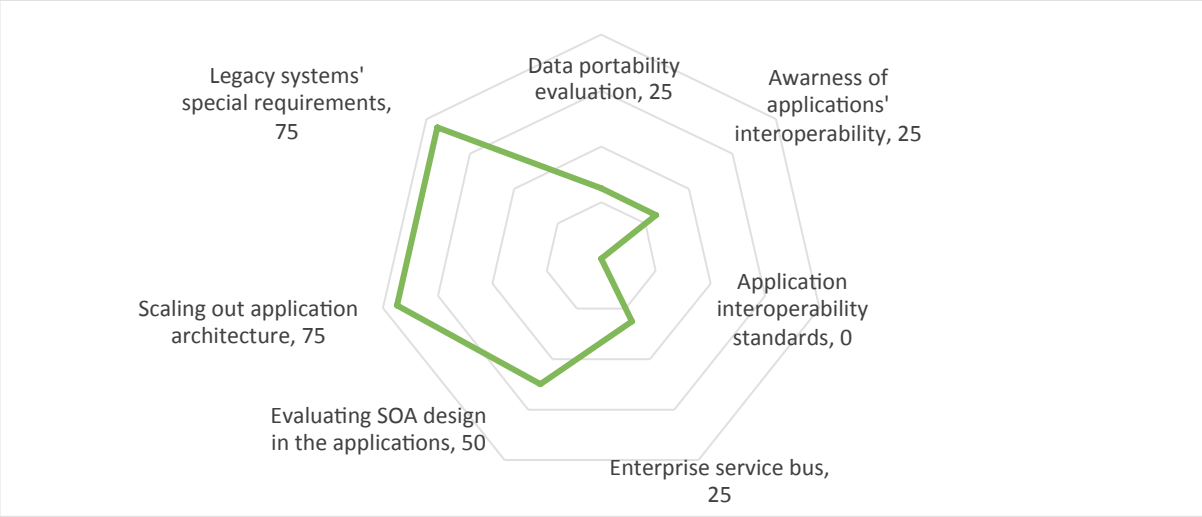



Figure 5: Interoperability readiness percentage score radar chart

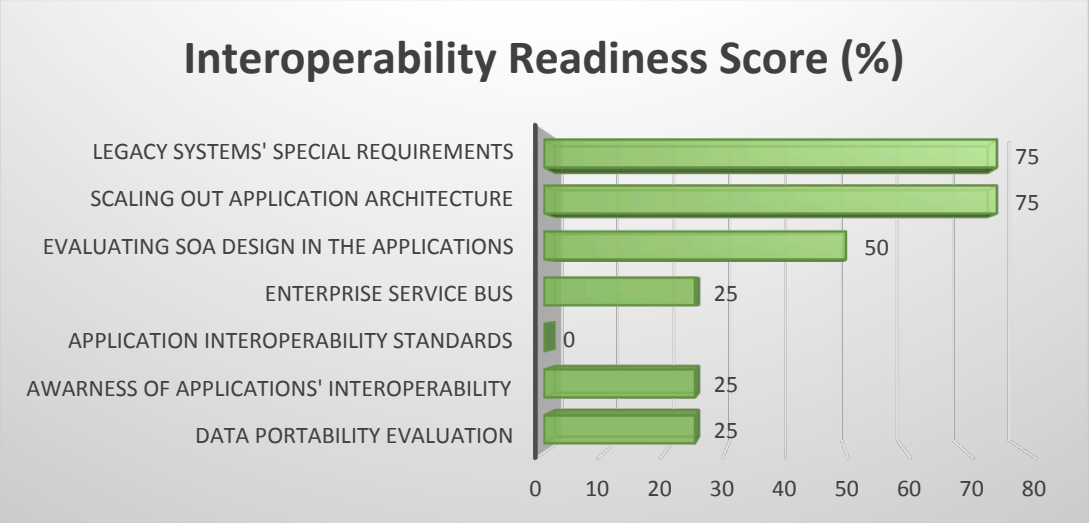



Figure 6: Interoperability security readiness percentage score bar chart

### Good Areas (75%):

1- The capability of the University application to scale out to different servers during spike workloads.
2- Identifying legacy systems that require special hardware.

> *"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

Adequate Areas (50%):

1- Evaluating the University systems that designed based on SOA.

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

Marginal Areas (25%):

1- Evaluating the portability level of the data in the University system against different cloud computing vendors' data format.
2- The consideration of implementing Enterprise Service Bus (ESB) to perform interface, protocol and data transformations to address differences between different cloud providers.
3- The identification of the required level of interoperability for the migrated applications based on the service models ( Low level SaaS, Meduim level PaaS and high level IaaS)

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

Inappropriate Areas (0%):

1- The awareness of standards to ensure interoperability of applications on the cloud e.g. (Open virtualisation Format (OVF), Cloud Data Management interface (CDMI).

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 3** In your opinion, do you believe the scores presented in this "IT Systems' Interoperability Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

# Section 4 SLA Readiness Score

This section shows the processes relevant to the SLA readiness. In this category, there are 8 processes as shown in radar and bar charts respectively.

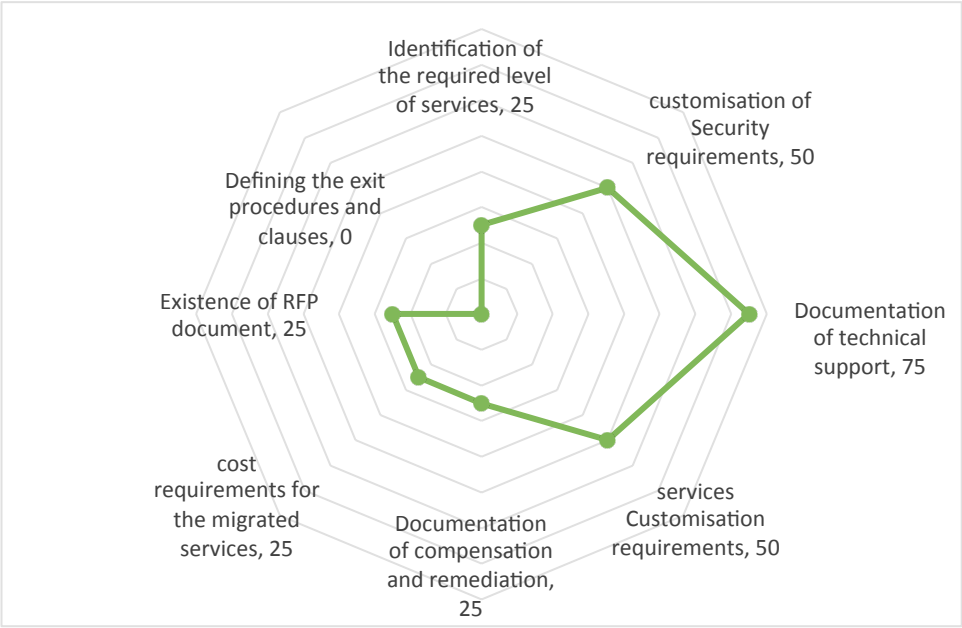



Figure 7: SLA readiness percentage score radar chart

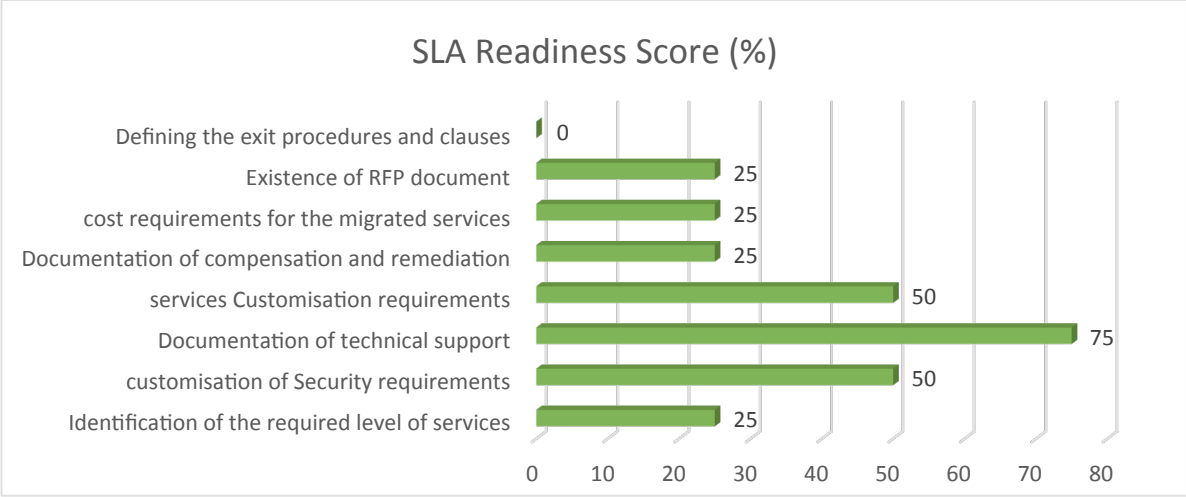



Figure 8: SLA readiness percentage score bar chart

### Good Areas (75%):

1- The documentation of the required cloud technical support from the cloud vendors

*"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

### Adequate Areas (50%):

1- Set up different customisation requirements for the University IT services that demand so.
2- The customisation of security requirements for each service migrated to the cloud e.g.(the ability to manage security terms in the cloud SLA).

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

Marginal Areas (25%):

1- The preparedness of RFP documents when dealing with different IT suppliers.
2- The identification of the required service level for the migrated services to the cloud e.g. (the expected availability time or locations).
3- The documentation of the required compensation and remediation when fault and failure occur (the penalties required if the guaranteed service level is not met).
4- Defining the satisfied cost requirements for the services migrated e.g. (accepted cost for: one unit of CPU unit, storage, RAM and network for each VM used).

*"The processes at this level is below average and require substantial improvement before migrating your system to the cloud"*

Inappropriate Areas (0%):

1- Defining the accepted get-out or exit procedures and clauses in the SLA contract e.g. (the time to move to another cloud provider or how to make sure the data is removed from the previous provider storage).

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 4** In your opinion, do you believe the scores presented in this "SLA Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

# Section 5 Migration Planning Readiness

This section shows the processes relevant to the Migration Planning readiness. In this category, there are 6 processes as shown in radar and bar charts respectively.

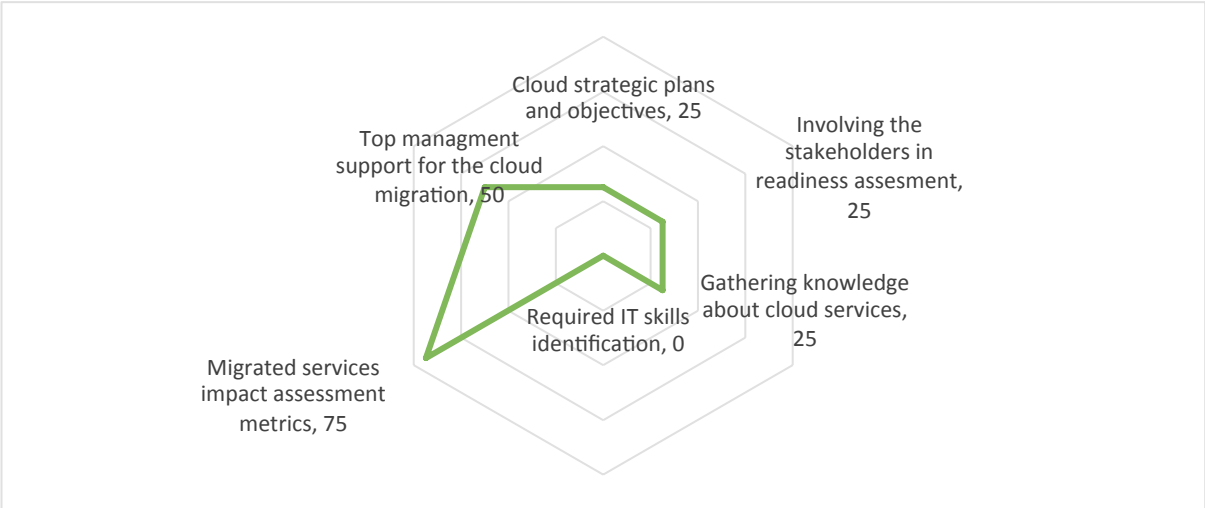



Figure 9: Migration planning readiness percent score radar chart

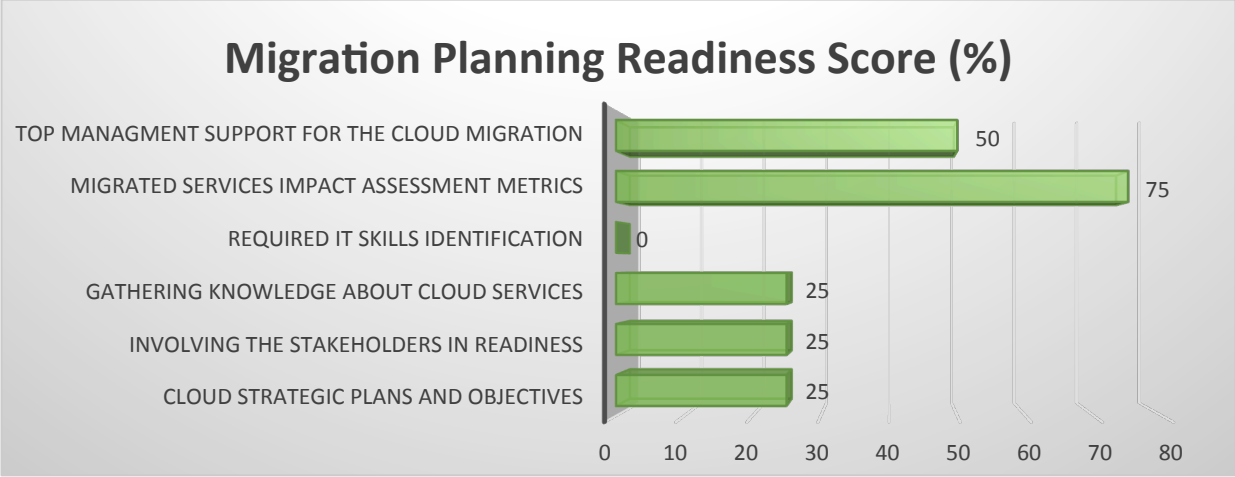



Figure 10: Migration planning readiness percent score bar chart

### Good Areas (75%):

1- Defining the suitable metrics to measure the impact of the migrated services e.g. (assessing cost savings or validate SLA compliance).

> *"The area is well-established; however, minor improvements may still be required to bring the process to the desired readiness level for cloud migration"*

### Adequate Areas (50%):

1- The support of board of directors to cloud migration project and investment in your University e.g. (Managing IS human resources, budget and objectives of cloud usage).

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

Marginal Areas (25%):

2- Establishing the strategic plans and objectives of cloud computing within the IT strategy.
3- Gathering intelligence on cloud services and providers offerings e.g. (structured resources such as successful migrated projects, Experts views, using evaluating tools e.g. SMICLOUD).
4- Involving the stakeholders (management board, IT staff, and employee) in assessing service readiness for the cloud.

*"The process at this level is below average and require substantial improvement before migrating your system to the cloud"*

Inappropriate Areas (0%):

1- The identification of the required IT skills to migrate to the cloud against the available skills (Developing required cloud skills Training Programs).

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 5** In your opinion, do you believe the scores presented in this "Migration Planning Readiness" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

# Section 6 Compliance with Regulations readiness Score

This section shows the processes relevant to the Compliance with Regulations readiness. In this category, there are 5 processes as shown in radar and bar charts respectively.

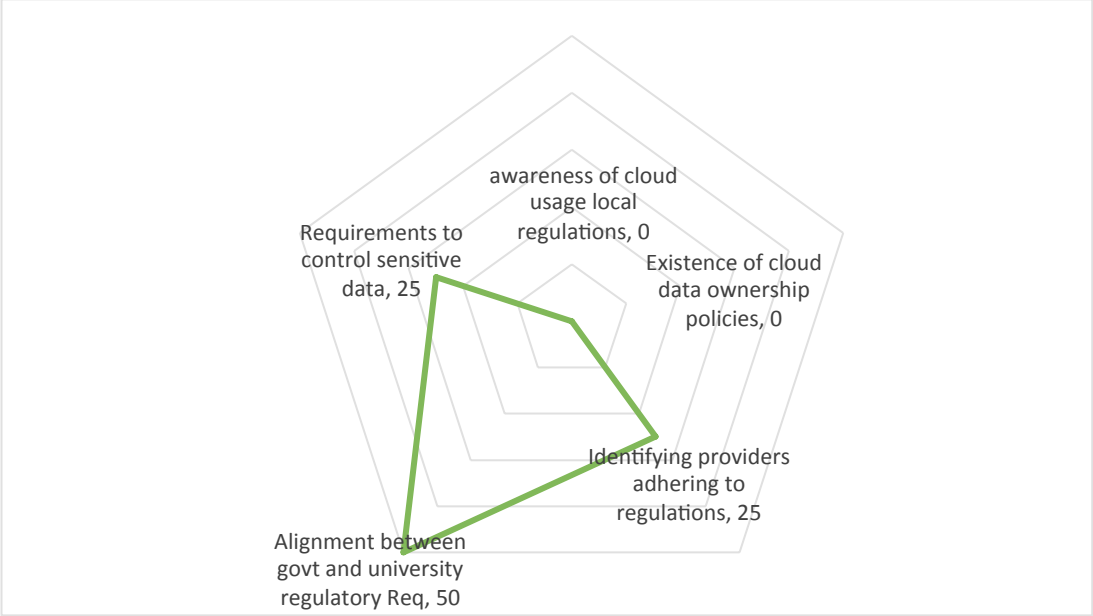



Figure1: Compliance with Regulations readiness percent score radar chart

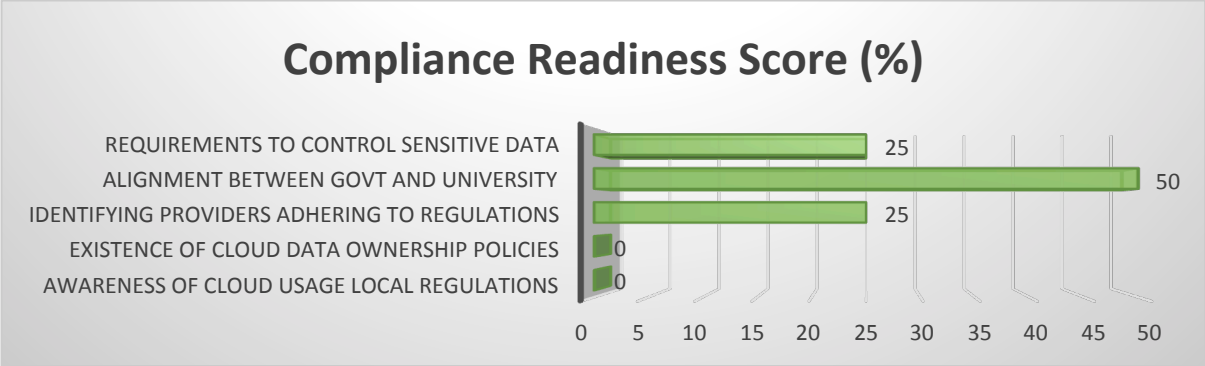



Figure2: Compliance with Regulations readiness percentage score bar chart

## Adequate Areas (50%):

1- The alignment between the organisation cloud requirements and the government legal and regulatory requirements including those related to security, privacy and accessibility.

*"The area remains at an average scale and needs considerable improvement to enable an appropriate cloud migration"*

### Marginal Areas (25%):

1- Defining the requirements to control the data over the functionality of the cloud services (how sensitive data will be controlled).
2- Identifying the cloud services and providers that adhere to the country regulations e.g. (licensed vendors).

*"The processes at this level is below average and require substantial improvement before migrating your system to the cloud"*

### Inappropriate Areas (0%):

1- Declaration policies to regulate the usage of the data on the cloud (Data ownership policies).
2- The identification of the local regulatory requirements to host or outsource to cloud services e.g. (awareness of cloud usage local regulations).

*"There are major issues and weakness areas and serious consideration is required to before migrating to the cloud"*

**Question 6** In your opinion, do you believe the scores presented in this "Compliance with Regulations" section reflect your true readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

## Section 7 Overall sections' score

After showing each of the readiness assessment criterion results, this section presents the overall readiness assessment results for the 6 criteria in the instrument. The radar and bar chart-based criteria scores are presented below.

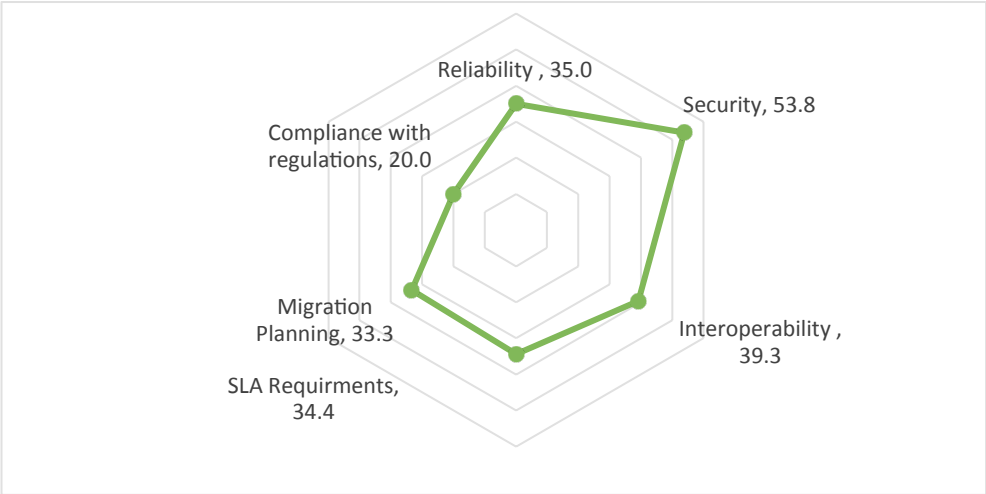



Figure 3: Overall assessment criteria percentage score radar chart

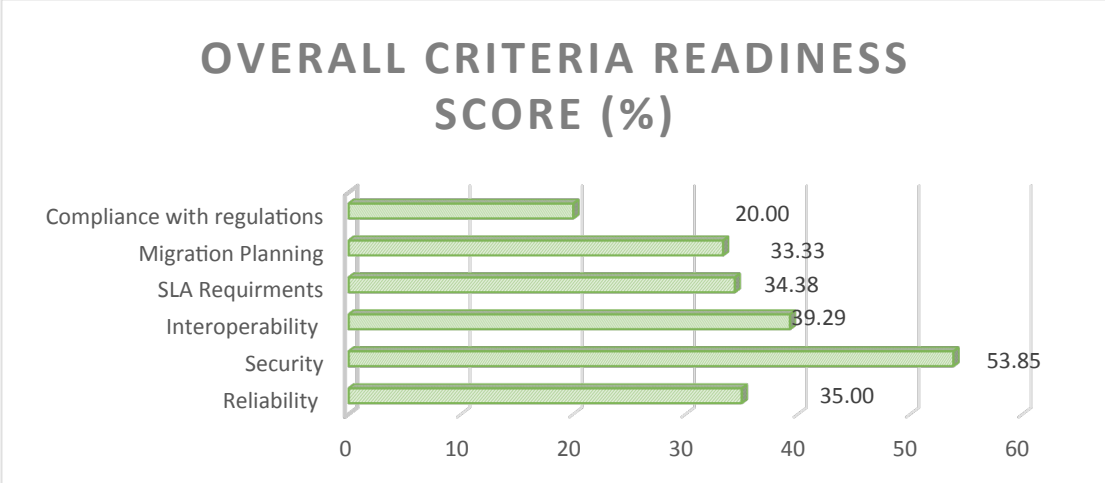



Figure4: Overall criteria score bar chart

**Based on the readiness assessment of all the assessment criteria, the overall readiness score percentage for your university is:**

**39.05%**

**''Average level of readiness for cloud migration, considerable improvements are needed for successful cloud migration project''**

**Question 7** In your opinion, do you believe the scores presented in this section reflect your actual and overall readiness level or capability to undertake the cloud migration in your university?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

**Question 8**: To what extent do you believe this instrument is useful in measuring weaknesses as well as strengths of the cloud migration process readiness within the Saudi universities' context?

- Strongly disagree
- Disagree
- Neutral Agree
- Strongly Agree

# Appendix J

## Instrument Evaluation Questionnaire

University Name:

Job Role:

Years of Experience:

Date:

This questionnaire is designed to collect feedback about the use of the cloud migration readiness tool. Your participation is essential; I will be thankful if you can complete the questionnaire and handed it back to the researcher.

Please Rate each of the following questions to correspond to the experience of using the tool. All items are measured on 1 – 5 scale where **1 is not at all** and **5 is completely.**

| | | | | | | |
|---|---|---|---|---|---|---|
| | Perceived Usefulness | | | | | |
| 1 | Using this tool helps assess the readiness status of my organisation for cloud migration. | 1 | 2 | 3 | 4 | 5 |
| 2 | Using this tool increase my awareness about the areas need to be assessed before the migration to the cloud. | 1 | 2 | 3 | 4 | 5 |
| 3 | Using this tool enhances my effectiveness in managing and assessing the cloud migration readiness status of our organisation. | 1 | 2 | 3 | 4 | 5 |
| 4 | Overall, this tool is useful in assessing and assuring the readiness level of our University for the cloud migration. | 1 | 2 | 3 | 4 | 5 |
| | Satisfaction | | | | | |
| 5 | I am satisfied about our organization readiness results after using the tool. | 1 | 2 | 3 | 4 | 5 |
| 6 | I am content with the experience of using the tool | 1 | 2 | 3 | 4 | 5 |
| 7 | Overall, How would you rate your overall satisfaction about the tool? | 1 | 2 | 3 | 4 | 5 |
| | Confirmation | | | | | |
| 8 | My experience with using the tool was better than what I expected | 1 | 2 | 3 | 4 | 5 |
| 9 | The service level provided by this tool was better than what I expected | 1 | 2 | 3 | 4 | 5 |
| 10 | Overall, most of my expectations from using this tool were confirmed. | 1 | 2 | 3 | 4 | 5 |

# Appendix K

## Seniors interview Questions

University Name:

Job Role:

Years of Experience:

Date:

- Can you tell us about the current processes/procedures of preparing to migrate to the cloud?

- What is your perception about the readiness status (in percentage) of your organisation for cloud migration before the assessment findings and results?

  In scale from 1 – 5 where 1 not confident at all and 5 fully confident, rate the level of confidence you have about the readiness of your organisation to migrate to the cloud:

| Not confident at all | | | | Fully Confident |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

- What is your perception about the readiness status of your organisation for cloud migration after the study findings and results?

  Now after you see the study results, In scale from 1 – 5 where 1 not confident at all and 5 fully confident, rate the level of confidence you have about the readiness of your organisation to the cloud:

| Not confident at all | | | | Fully Confident |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

- How did you find the researcher's cloud migration readiness assessment Instrument?