THE DESIGN, DEVELOPMENT AND EVALUATION OF A HOLISTIC CLOUD MIGRATION DECISION FRAMEWORK

By

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THE DESIGN, DEVELOPMENT AND EVALUATION OF A HOLISTIC CLOUD MIGRATION DECISION FRAMEWORK

I declare that the above dissertation is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the thesis to originality checking software. The resulting summary is attached.

I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other higher education institution.

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I want to thank my supervisor, Dr JC Mentz, for guiding me throughout the process and not giving up on me when the road was hard. Academic research is a field I have always wanted to learn and improve on and this dissertation has afforded me that opportunity.

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It has been a long and fruitful journey and I hope that the contribution made by this paper is beneficial to academic and practitioner research.

Dedication

This is for me

Abstract

Cloud Computing has gained traction since its emergence and client organisations that want to benefit from the Cloud are looking for ways to migrate their on-premise applications to the Cloud. To assist client organisations with migration projects, researchers and practitioners have proposed various Cloud migration approaches. However, these approaches differ in applicability depending on the type of application being migrated and the Cloud Service Provider where the application is being migrated to. The various approaches to Cloud migration create complexity in Cloud migration decisions as client organisations have to consider various approaches depending on the migration project. The purpose of this dissertation is to create a universal Cloud migration approach that can be applied to every Cloud migration project. In this dissertation, a cloud migration decision framework is proposed; namely, A Holistic Cloud Migration Decision Framework (HCMDF). The research strategy that was followed is Design Science Research (DSR) and was selected since the output of the research is going to be an Information Technology (IT) research artefact. By applying the DSR strategy, the HCMDF was successfully developed and evaluated in the real world using an adaptive case study. The analysis of the results indicated that the HCMDF solves Cloud migration problem and that it can be applied to every Cloud migration project. Throughout the evaluation, areas of improvement were identified and these will be considered in future research.

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List of Abbreviations

AAR	Account Rate of Return
API	Application Programming Interfaces
AST	Agreed Service Time
AWS	Amazon Web Services
Bps	Bits Per Second
BSC	Balanced Scorecard
CC	Cloud Computing
CRM	Customer Relationship Management
CSP	Cloud Service Provider
DAPS	Distributed Platforms and Services
DC	Design Criteria
DDoS	Distributed Denial of Service
DSR	Design Science Research
DT	Downtime
DTMF	Distributed Management Task Force
EC	Evaluation Criteria
FEDS	Framework for Evaluation in Design Science
GC	Grid Computing
HCMDF	Holistic Cloud Migration Decision Framework
IaaS	Infrastructure as a Service
IIR	Internal Rate of Return
IQ	Interview Question
ISO	International Organisation Standardisation
IT	Information Technology
MIS	Management Information Systems

MTTR	Mean Time To Repair
NIST	National Institute of Standards and Technology
NPV	Net Present Value
OCC	Open Cloud Consortium
PaaS	Platform as a Service
PD	Problem Description
PP	Payback Period
QoS	Quality of Service
RAM	Reliability, Availability and Maintainability
REST	Representational State Transfer
RO	Research Objectives
ROI	Return on Investment
SaaS	Software as a Service
SC	Solution Criteria
SLA	Service Level Agreement
SME	Small and Medium Enterprise
SOA	Service Oriented Architecture
VM	Virtual Machine
VMAN	Virtualization Management Initiative
VT	Virtualization Technology
WSDL	Web Service Description Language
XaaS	Anything as a Service

CHAPTER 1: INTRODUCTION

1.1 Introduction and Background

Cloud Computing (CC) is a type of computing where computing services are made available over the internet as a shared pool of Information Technology (IT) resources (Araujo et al., 2018). IT resources refer to the hardware, development platforms and applications that are made available in the Cloud by the Cloud Service Provider (CSP) (Schneider and Sunyaev, 2016). "The Cloud" refers to the CSP's data centre containing the hardware and software hosting IT resources (Armbrust et al., 2010). The users of CC can be CSPs, people, or client organisations (Armbrust et al., 2010). For the remainder of this dissertation, the focus on Cloud users is on "client organisations", therefore client organisations will refer to organisations that are planning to migrate applications hosted on their premises to the Cloud. The term "on-premise applications" will therefore refer to the client organisation's applications that are hosted within the client organisation's data centre.

CC provides client organisations access to affordable, scalable and agile technology (Nedbal et al., 2014). CC resources are made available to client organisations on demand and on a pay-per-use basis (Araujo et al., 2018., Schneider and Sunyaev, 2016). The advantage of a pay-per-use basis is that client organisations can closely match their evolving needs for computational resources as their workload changes, compared to sizing solutions for worst-case scenarios (Tak et al., 2011). Client organisations experience a cost benefit because they only pay for the resource when it is used. The cost of running IT systems is therefore reduced, since CC eliminates the cost of hardware purchases, hardware maintenance, software, system upgrades, software licenses, and data storage (Yeboah-Boateng and Essandoh, 2014).

There are three main service offerings in the Cloud; namely, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) (Schneider and Sunyaev, 2016). IaaS, PaaS and SaaS are collectively referred to as Cloud service delivery models (Zhao and Zhou, 2014). Araujo et al. (2018) identified the top CSPs investing in CC services as being Google (Google Cloud, 2020), Amazon (Amazon, 2020), and Microsoft

(Microsoft, 2020). Kumalo (2018) states that IBM has implemented CC data centres in China, India, Vietnam, Brazil and South Korea; and Microsoft, VMWare, Salesforce, Dell and Odin are actively searching for CC opportunities in developing countries.

Client organisations that want to benefit from CC need to devise strategies on how to migrate on-premise applications to the Cloud. The process of migrating existing applications to the Cloud requires a client organisation to select the most suitable applications to fit in the Cloud environment (Panori et al., 2016). Application migration strategies are provided by the CSPs through guidelines, documentation, and procedures that apply to specific types of applications and a specific Cloud platform. For example, Amazon has a series of documents called the AWS Prescriptive Guidance (AWS, 2019) that provide procedures for migrating specific applications to the AWS Cloud. The same approach is followed by IBM (IBM, 2020), Microsoft (Microsoft, 2020), and RedHat (RedHat, 2020) by providing documentation on how to migrate specific applications to their Cloud platforms. This proprietary approach, however, may create a "silos" understanding of Cloud migration as it offers no universal Cloud migration approach across different CSPs.

Researchers, like CSPs, have also proposed varying approaches to Cloud migration. Some of these approaches focus on a starting point for Cloud migration. The migration approach suggested by Beserra et al. (2012) considers organisational constraints a starting point that might influence the organisation's ability to adopt Cloud solutions. The organisational constraints that Beserra et al. (2012) consider a starting point for Cloud migration are organisational policies, guidelines, rules, procedures, and legislation. Varia (2010) suggests a Cloud migration approach that considers the application portfolio as a starting point. By assessing applications, a client organisation can determine which applications are eligible for migration to the Cloud because not all applications are eligible for the Cloud (Martson et al., 2011.; Varia, 2010). For example, some applications may have hardware dependencies as they are built within company data centres or co-located facilities (Varia, 2010). Legacy applications and third-party applications are examples of applications that are difficult to migrate to the Cloud compared to general-purpose applications like Microsoft Office, email and collaboration technologies (Martson et al., 2011). General-purpose applications are better candidates for Cloud migration because there are no features of the application that is specific to an organisation (Martson et al., 2011).

The various processes of Cloud migration are a challenge for both researchers and practitioners as it makes it difficult for researchers and practitioners to synthesize, digest and fully comprehend the Cloud migration process (Gholami et al., 2018).

1.2 Chapter Layout

The remainder of this chapter is structured as follows: Section 1.3 describes the problem statement, Section 1.4 describes the research strategy, and the chapter will conclude with a chapter summary.

1.3 Problem Statement and Research Questions

The research problem will be labelled as RP:

RP = *There is no universal process for migrating on-premise applications to the Cloud*

The various processes toward Cloud migration provide a contrasting fact to Cloud migration, thus making it clear that there is no universal process for the migration of on-premise applications to the Cloud. Client organisations planning to migrate on-premise applications to the Cloud have to follow proprietary migration guidelines set by specific CSPs, thereby creating disagreement on the appropriate migration process to follow. There is, therefore, a need for a Cloud migration process that is not dependent on a proprietary process by a specific CSP.

To develop a universal process, a literature review (Chapter 2) is conducted to determine the challenges of migrating on-premise applications to the Cloud. The challenges of migrating on-premise applications to the Cloud are depicted in Figure 1. The way that a universal approach will be addressed is by addressing the challenges for Cloud migration. Cloud migration challenges will be addressed in this dissertation by developing solutions that will address each of the migration challenges. There is consequently a need to specify what criteria must be met to conclude how decisions to migrate to the Cloud are addressed. The solution criteria to be met for a universal approach to Cloud migration are labelled Solution Criteria (SC) and they are listed as follows:

- **SC1** - Provide clear selection criteria for applications to be migrated to the Cloud
- **SC2** - Provide clear motivation and drivers for migration intend
- **SC3** – Provide clear guidelines to select the appropriate migration approach based on the application

- **SC4** - The framework should apply to organisations in any industry of any size

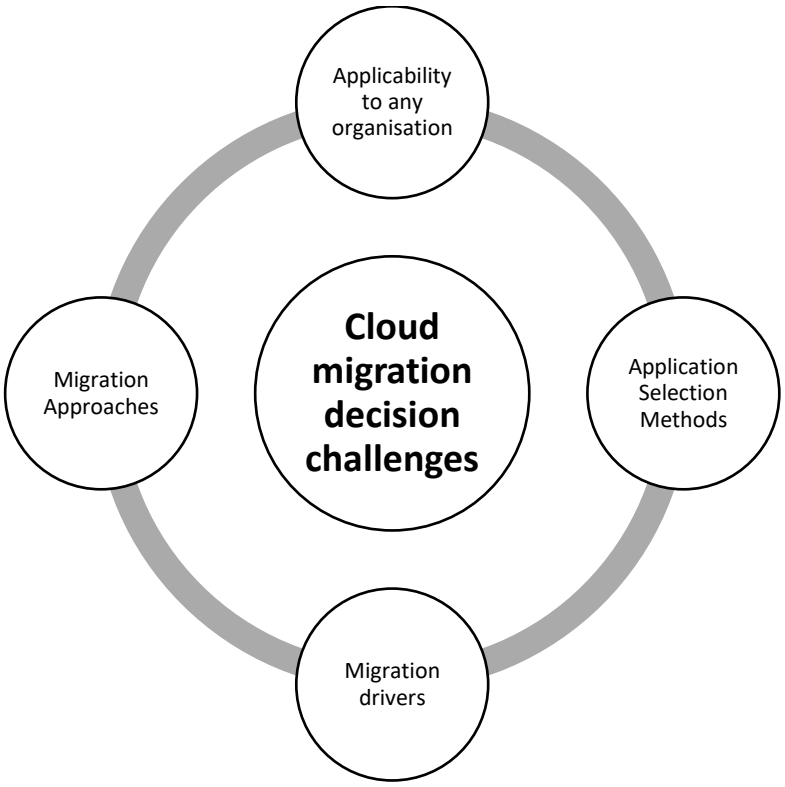

Figure 1.1: Cloud Migration Decision Challenges

The research objectives

- **RO1** - Study the criteria used to make a selection of applications applicable for Cloud migration
- **RO2** - To assess organisational drivers and motivation for Cloud migration
- **RO3** - Study approaches to migrate on-premise applications to the Cloud

1.4 Research Strategy

The research strategy followed in this dissertation is Design Science Research (DSR) process by Vaishnavi et al. (2019). The process is depicted in Figure 1.2. The Awareness of Problem step was conducted by performing a literature review on Cloud computing migration. Through the literature review, the problem of the lack of uniformity in Cloud computing migration was identified. The Output of the Awareness of Problem step is a research proposal. The Suggestion step involved designing a high-level overview of the artefact to solve the Cloud migration problem. The development stage provides detailed steps of the

design of the artefact to solve the Cloud migration decision problem. In the Evaluation step, the artefact designed is evaluated by conducting an adaptive case study, followed by interviews. The data collected is then analysed by looking for a specific pattern to determine the efficacy of the artefact in a real-world situation. The results are then summarised and presented as findings. The Conclusion step provides a summary and outcome of the evaluation of the artefact as well as whether the artefact was successful in solving a Cloud migration problem.

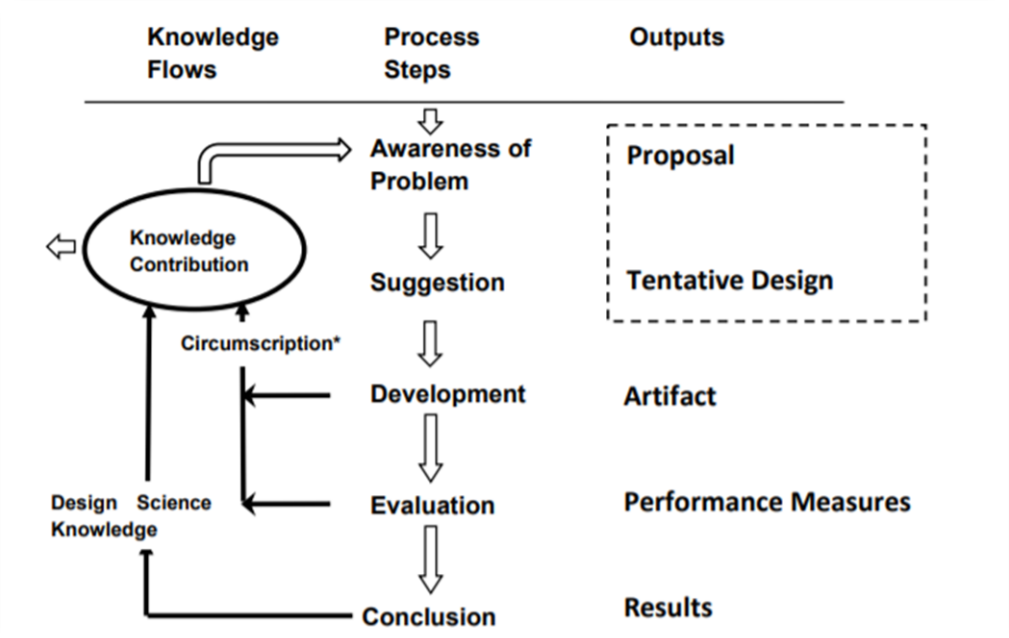

Figure 1.2: Design Science Research Process Model (DSR Cycle) (Vaishnavi et al., 2019).

1.5 Chapter Summary and Dissertation Structure

The remainder of the dissertation is structured as follows:

- **Chapter 1** provides an overview and introduction of the research problem and research objectives of CC migration decision-making.
- **Chapter 2** provides background information on CC by exploring the CC definition, characteristics, enabling technology, stakeholders, standards, drivers, benefits, challenges, migration strategies, and migration problems.
- **Chapter 3** discusses the research strategy. This section explores a brief history of the chosen research strategy and the justification for its use in this dissertation. The

research strategy map and process is discussed to give direction on how the research strategy will be approached and applied.

- **Chapter 4** presents the design of the artefact. Background information is provided in the form of building blocks for the artefact. The building blocks are then put together to design and build the artefact.
- **Chapter 5** provides a methodology for testing the efficacy of the artefact. The purpose of this chapter is to present the artefact to a group of decision-makers in Company A. The design of the evaluation instrument is presented; which provides details on how the data was collected and the interview questions that were asked. Upon data collection, the chapter provides an analysis of the data and communicates the results.
- **Chapter 6** provides the conclusion of the dissertation. The conclusion discusses how the objectives set out in Chapter 1 are met and provides direction for future research. This is then followed by the References and Appendix sections.

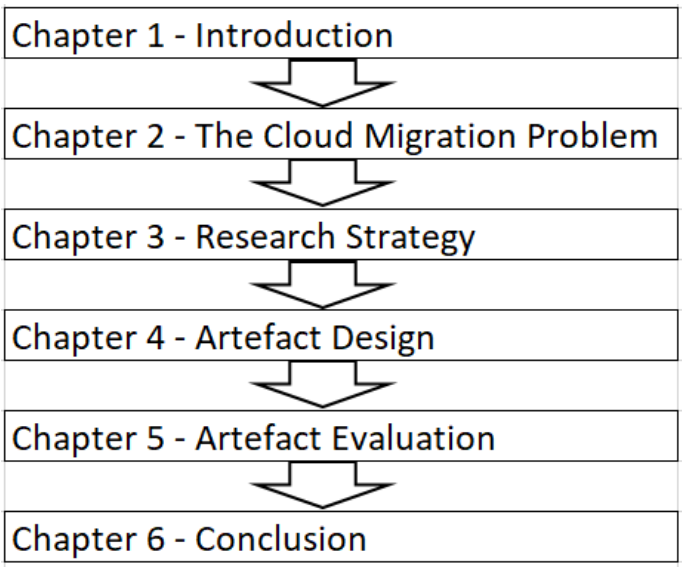

Figure 1.3: Dissertation Mind Map

CC client organisations do not have a universal approach for the migration of on-premise applications to the Cloud. The client organisations considering migrating on-premise applications to the Cloud have to select a suitable migration approach amongst various

migration approaches from research and practitioner community. The lack of a universal migration approach to the Cloud presents an opportunity to develop a Cloud migration decision framework that solves this problem.

CHAPTER 2: THE CLOUD MIGRATION PROBLEM

2.1 Introduction

Researchers and practitioners provide various approaches for client organisations to migrate their on-premise applications to the Cloud. These various Cloud migration approaches are not universal – they have different approaches for diverse Cloud migration needs. Each CSP provides proprietary approaches to Cloud migration depending on the type of application that will be migrated to their respective Clouds (Section 1.1). Therefore, different applications will follow different migration approaches, thus no single approach is applicable to every type of migration. Without a universal approach to migration, client organisations have to analyse each approach from different CSPs therefore increasing the complexity of migration applications to the Cloud. Simple applications such as e-mail applications can easily be migrated to the Cloud where there is a Software solution already available in the Cloud; however, complex applications need elaborate planning as well as testing prior to migration (Rashmi et al., 2012).

An improper approach to Cloud migration can negate the cost savings envisaged for the Cloud since hidden operational costs for running applications on the Cloud might be overlooked (Rashmi et al., 2012). The cost of migrating on-premise applications will increase as the organisation will be reliant on the expertise of the CSP or Cloud consultants for the best approach for migration. The challenges with migration will also affect project timelines, thus exacerbating the cost of migration. Williams (2012) classified the cost related to Cloud migration into the categories of direct costs and that of indirect costs. Direct costs refer to hardware, application maintenance, variable expenses, as well as less quantifiable costs like software porting efforts, application migration efforts, and more application complexity (Tak et al., 2011). Indirect costs are quantifiable costs related to infrastructure, staff salaries, variable expenses, and less quantifiable costs such as Cloud performance changes, possible vulnerability, and various time delays (Tak et al., 2011). From a cost perspective, the client organisation has various costs to consider. Therefore, not applying a universal approach to Cloud migration can lead to the client organisation failing to consider all possible costs of the migration.

A Cloud migration that is not done properly can have negative consequences for the client organisation since they can experience unplanned outages resulting in revenue loss and reputational damage. Without applying a universal approach to Cloud computing, the client organisation will not be fluent in and have a mature approach to migration due to different approaches being applied for different applications. It is therefore necessary that the migration of an on-premise application is conducted successfully by following a universal approach that is repeatable across organisations and various types of migrations. The solution that is proposed in this dissertation, is a Cloud migration decision framework which will allow client organisations to use a universal approach to the Cloud migration of on-premise applications.

The following approach was applied in the literature review. A literature review was conducted by searching web content on the UNISA *e-library* (UNISA, 2020) and *Google Scholar* (Google, 2020) databases. Both databases have different content on Cloud computing. Whereas the UNISA (2020) library has more research publications in academia, Google (2020) provides research publications for both researchers and practitioners. Considering that practitioners also provide guidance on Cloud migration, it was essential to capture content from researchers as well as scholars .

The CC definition was considered the first step since it provides a foundation of the basic principles that are discussed in the remainder of the dissertation. The CC definition is then followed by the background information on CC by explaining the concepts of CC, the benefits of CC to client organisations, the challenges of CC, CC migration, and finally, the challenges with migrating on-premise applications to the Cloud. The last part of this chapter focuses on the problem that this paper is solving, which is the lack of a universal approach to Cloud migration.

This chapter is structured as follows: Section 2.2 will present the definition of Cloud computing, Section 2.3 Cloud deployment models, Section 2.4 presents the characteristics of Cloud computing, Section 2.5 discusses Cloud-enabling technologies, Section 2.6 discusses the Cloud characteristics, Section 2.7 proposes the organisational benefits of CC, Section 2.8 discusses Cloud computing challenges, Section 2.9 discusses concerns in migrating to the Cloud, and Section 2.10 discusses Cloud migration strategies.

2.2 Definition of Cloud Computing

CC is a computing paradigm that provisions virtualized computing resources in the form of a pay-as-you-go service that is accessible remotely over the internet (Beserra et al., 2014). These virtualized computing resources refer to a pool of easily usable and accessible Information Technology (IT) hardware, software development platforms and applications (Zhao and Zhou, 2014). The data centres hosting these computing resources are referred to as the Cloud (Armbrust et al., 2009). Access to the Cloud is through the internet using simple and pervasive methods (Wang et al,, 2010). The Cloud provides a shift from a traditional IT on-premise model where organisations own and operate all IT resources to offering IT services in the Cloud (Feuerlicht et al,, 2011).

There is no universal definition of CC as different authors have expressed it in different ways (Hashemi and Bardsiri, 2012). Although there is no common definition of Cloud computing, the widely cited definition for Cloud computing is that from the National Institute of Standards and Technology (NIST) (Mell and Grace, 2011), (Miyachi, 2018). NIST defines CC as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be provisioned rapidly and released with minimal management effort or service provider interaction. CC is composed of five essential characteristics, three service models, and four deployment models (Mell and Grace, 2011). The characteristics, service models and deployment models are discussed in Sections 2.2.1, 2.2.2 and 2.2.3. Figure 2.1 depicts the definition of CC as defined by NIST (Hashemi and Barsiri, 2012).

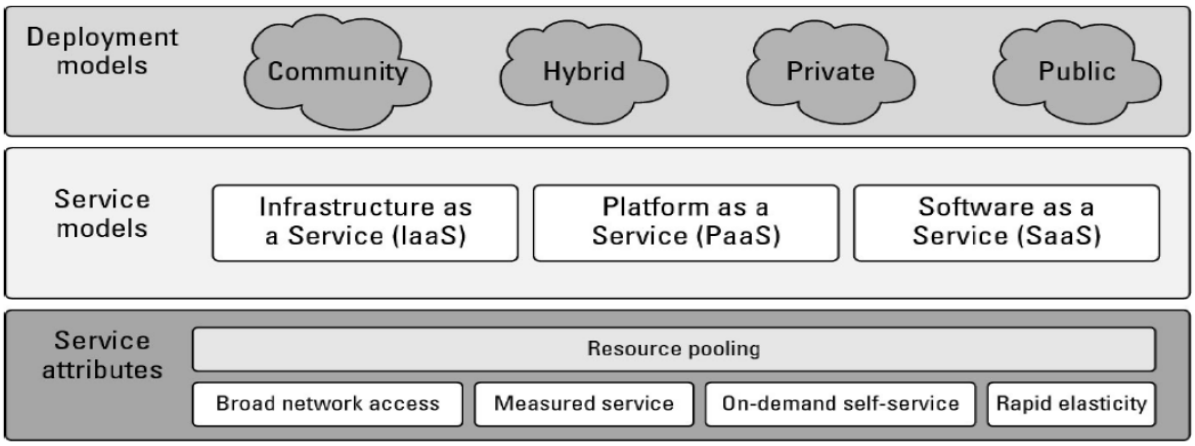

Figure 2.2: NIST Cloud Computing Definition (Hashemi and Bardsiri, 2012).

The next section explores the terms service models, service attributes, and deployment models as described in the Cloud definition by NIST.

2.2.1 Cloud Service Models

The services that were traditionally delivered by on-premise IT infrastructure are now being delivered over the internet as Anything as a Service (XaaS) (Miyachi, 2018). Rimal et al. (2009) refer to XaaS as infrastructure, platform, software, data, business, and any other services that are offered on the internet. Rahko (2016) refers to XaaS as Everything as a Service. There is no specific number of Cloud services available since every service on the internet is offered as a Cloud service, however, the three common Cloud services are Infrastructure as a Service (IaaS) (Section 2.2.1.1), Platform as a Service (PaaS) (Section 2.2.1.2), and Software as a Service (SaaS) (Section 2.2.1.3), (Krishna et al., 2016., Garn, 2017).

2.2.1.1 Infrastructure as a Service (IaaS)

IaaS is based on virtualization technology (AlMorsy et al., 2016) and provides the client organisation with infrastructure such as processing, storage, network, and other fundamentals – thereby allowing the client organisation to deploy their operating systems and arbitrary software (Mell and Grace, 2011). The underlying infrastructure is managed by the CSP (Vignos et al., 2016). Although the client organisation does not manage the Cloud infrastructure, they have control over operating systems, storage and deployed applications but limited control over other networking components such as host firewalls (Mell and Grace, 2011). The benefit of IaaS is that the CSP uses the latest technology which, in turn, provides the client organisation with the ability to improve service delivery and speed up the time to market of new services (Riaml et al., 2009). Amazon EC2 (AWS, 2020) and Google Compute Engine (Google, 2020) are examples of CSPs that provide IaaS services (Zhang et al., 2013).

2.2.1.2 Platform as a Service (PaaS)

The PaaS platform offers an operating platform where client organisations can create their own applications by using development tools provided by the CSP (Bredner and Markov, 2013). The client organisation benefits from reduced development times as the Cloud service

is equipped with readily available tools to develop new products and services (Rimal et al., 2009). The PaaS platform allows the client organisation to focus on building application logic while the CSP manages the Cloud (Kavis, 2014).

The client organisation can deploy to PaaS consumer-created or acquired applications using programming languages, libraries, services and tools supported by the CSP (Mell and Grace, 2011). The client organisation's development team is responsible for the full development of applications that will be hosted in the Cloud, therefore, choosing the right platform for the client organisation is an important decision to make. PaaS provides client organisations with plugins, add-ons or extensions during the virtual machine build; which gives the client organisation the ability to access third-party solutions without having to make additional purchases (Kavis, 2014).

2.2.1.3 Software as a Service (SaaS)

SaaS is the most visible service in the Cloud as it directly interfaces with the end-users of the Cloud service (Landis and Blacharski, 2013). SaaS allows the client organisation to access the application running in the Cloud by using various client devices such as a web browser or program interface (Mell and Grace, 2011). The most common SaaS includes applications such as Customer Relationship Management (CRM), Management Information Systems (MIS), Gmail, Hotmail, Webmail and a range of other applications that are available on the internet as a service (Bredner and Markov, 2013; Zhang et al., 2013).

SaaS is also commonly referred to as an Application Service Provider (ASP) and a new software distribution platform (Rimal et al., 2009). Webmail (2020) is amongst popular SaaS solutions (Lewis, 2010). The client organisation manages limited user-specific application configuration settings while the rest of the functions are managed by the CSP, for example, Cloud infrastructure network, server, operating systems, storage or individual application capabilities (Mell and Grace, 2011). The burden of delivering quality services and safeguarding customers' data is carried by the CSP, unlike in traditional on-premise software models where the burden is on the organisation (Hugos & Hulitzky, 2010).

2.3 Cloud Deployment Models

The definition of Cloud computing by Mell and Grace (2011) includes the concept of Cloud deployment models. A Cloud deployment model defines the purpose of the Cloud and the way the Cloud is deployed (Hashemi and Bardsiri, 2012). NIST describes four Cloud

deployment models, namely public, private, community and hybrid Cloud (Mell and Grace, 2011). A client organisation that intends to migrate to the Cloud has the option to choose which deployment model is best suited for their business requirements (Kumalo, 2018).

2.3.1 Public Cloud

Public Cloud is provisioned for public use and it is built on the premises of the CSP (Mell and Grace, 2011). The public Cloud is therefore owned and operated by the CSP (Vignos et al., 2013.; Hashemi and Bardsiri, 2012). This type of Cloud service can also be provided free of charge, for example, Google's Gmail (Vignos et al., 2013). The public Cloud can also be offered on a pay-per-use basis (Armbrust et al., 2009). The user only pays for what they use (Jadeja and Modi, 2012) similar to how electricity and telephone companies sell voice and data services (Plummber et al., 2008). The client organisation does not have complete control of its data but may mitigate this risk by putting noncritical data in the public Cloud and leaving critical data on the private Cloud (Shoniwa, 2016).

2.3.2 Private Cloud

A private Cloud may be hosted on or off the premises of the client organisation and it is provisioned for the exclusive use of a single organisation which can comprise multiple users (business units) accessing the Cloud (Mell and Grace, 2011). The private Cloud is located behind the client organisation's firewall (Mell and Grace, 2011). The advantage of a private Cloud is that it is easier to manage security, maintenance and upgrades as well as its deployment and use (Jadeja and Modi, 2012). The private Cloud has an advantage over the public Cloud as there are no issues with regulations around data, privacy and security (Kavis, 2014). Privacy is maintained due to the consumer retaining control of their data (Shoniwa, 2016). The private Cloud has fewer benefits in terms of cost reduction and scalability but regulatory requirements are easier to adhere to (Schneider and Sunyaev, 2014).

2.3.3 Community Cloud

A community Cloud is shared by several organisations with a common purpose which also results in lower cost since those can be shared between organisations (Vignos et al., 2013). The community can build the Cloud because of shared mission, security requirements, policy

and compliance, and the Cloud can be managed by one or more organisations in the community (Mell and Grace, 2011).

2.3.4 Hybrid Cloud

A hybrid Cloud makes use of on-site and off-site resources (Vignos et al., 2013). The distinct CSP's making up the hybrid Cloud are bound together by proprietary technologies that enable data and Cloud portability (Mell and Grace, 2011). For the best results, a hybrid Cloud could use the public Cloud as much as possible to leverage the benefits provided by the public Cloud and leverage the private Cloud in cases where data privacy and ownership is important (Kavis, 2014).

2.4 Characteristics of Cloud Computing

According to Mell and Grace (2011), CC has five characteristics, namely, *on-demand self-service, broad network access, resource pooling, rapid elasticity and measured service*. *On-demand self-service* refers to a client organisation's ability to provision computing capabilities such as server time and network storage without requiring human interaction with the CSP (Mell and Grace, 2011). *Rapid elasticity* is defined by Herbst et al., (2013) as the degree to which a system is able to adjust to workload changes by provisioning and de-provisioning resources automatically, such that the computing resources will match the current workload demand as closely as possible. Scalability allows the Cloud application to be able to handle a large number of requests and it has two dimensions namely: horizontal scalability and vertical scalability (Kumar and Sharma, 2018). Horizontal scalability refers to the ability of the Cloud to increase resources of the same type, such as initiating more virtual machines during peak load (Ghahramani et al., 2017). Vertical scalability refers to the ability of increasing the Cloud capacity (Lorido-Botran et al., 2014). To the organisation, Cloud resources are unlimited and can be provisioned in any quantity at any time (Mell and Grace, 2011).

Resource pooling makes it possible for computing resources such as storage, processing, memory and network bandwidth to be pooled to serve multiple organisations (Mell and Grace, 2011). *Measured service* provides resource metering capabilities whereby CC resource usage can be monitored, controlled, and reported; thereby providing transparency between the CSP and the organisation using the Cloud service (Mell and Grace, 2011). This resource usage is automatically monitored and optimised as needed (Alam et al., 2015).

Broad network access means that Cloud capabilities are available over the network or internet and accessed through standard mechanisms like mobile phones, tablets, laptops and workstations (Mell and Grace, 2011).

2.5 Cloud-Enabling Technologies

There is an evolution of countless technology innovations brought about by CC (Diaby and Rad, 2017). The enabling technologies that make CC reliable, adaptable and usable are Virtualization Technology (VT), Service Oriented Architecture (SOA) and Grid Computing (GC) (Malik et al., 2018). Sections 2.5.1 to 2.5.3 will discuss VT, SOA and GC as they relate to CC.

2.5.1 Virtualization

VT enables the abstraction or decoupling of an application from the underlying physical resource (Sharma, 2015). VT enables the sharing of physical resources in such a way that the client organisation can utilise and customise its virtual resources in a similar fashion to its physical resources (Malik et al., 2018). The concept of virtualization can be explained by examining the concept of server virtualization. Server virtualization allows a physical server to be partitioned into multiple virtual computers called virtual machines (Rittinghouse and Ransome, 2017). The guest software runs on the virtual machine as a complete operating system just as it would on a stand-alone computer, thus each virtual machine has its own applications that are installed on the operating system (Rittinghouse and Ransome, 2017). The virtual machine and hardware resources are therefore carved up into logical or virtual resources and the provisioning of these resources can be made dynamic which can increase or decrease per workload requirements (Sharma, 2015).

Virtualization is enabled by a thin software layer called a hypervisor which allows many Virtual Machines (VM) to operate on just one physical server (Hugos and Hulitzky, 2010). The application still gets to operate as if it is accessing a dedicated processor, network and storage drives, but the hypervisor controls the application needs. Virtualization allows Clouds to run multiple numbers of user applications and for all the applications to appear as if they run simultaneously. It also allows the hardware to be unified as a pool of resources and resource overlays (Foster et al., 2008). By partitioning the hardware into individual virtual machines, the application can be encapsulated which improves security, manageability and isolation (Foster et al., 2008). Figure 2.5 depicts server virtualization where a physical

machine has been virtualized into multiple virtual machines sharing the same resources of the physical machine.

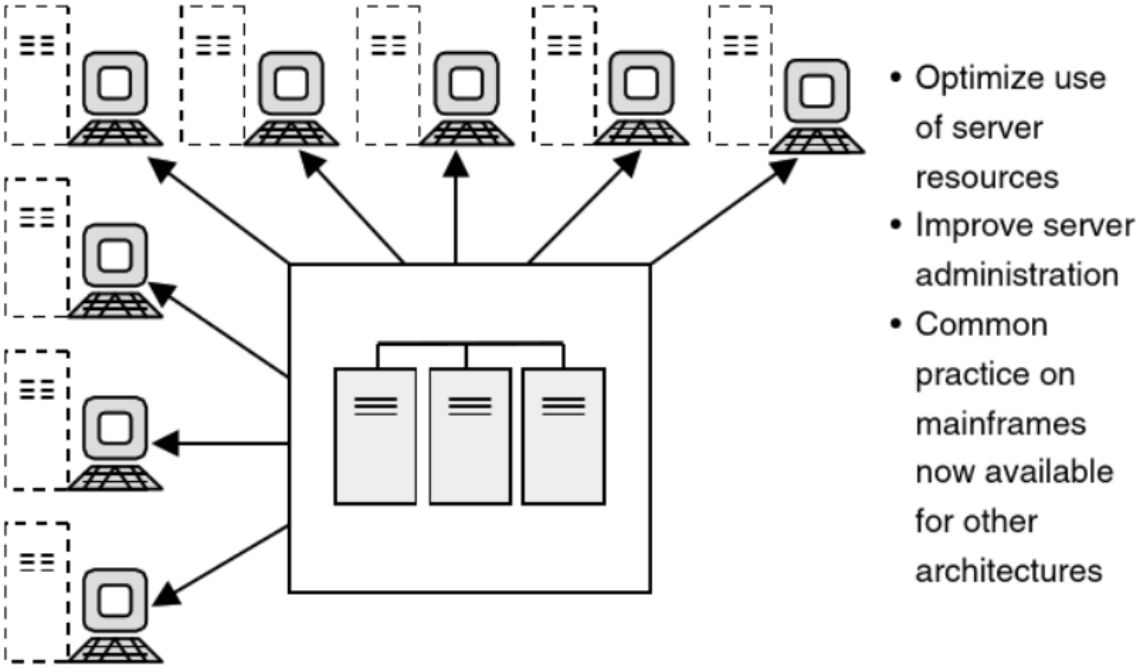

Figure 2.3: Server Virtualization (Hugo & Hulitzky, 2010)

Client organisations use VT within their own data centres to virtualize physical servers into multiple VMs. CSPs use VT to virtualize physical servers in their own data centres in the same fashion that the client organisations make use of VT. The hypervisor layer is abstracted and the CSPs provide their own management console for managing Cloud infrastructure.

2.5.2 Service-Oriented Architecture

Service-Oriented Architecture (SOA) allows network services to be leveraged by enterprise applications to enable business capabilities to be provided and consumed as a set of services (Rittinghouse and Ransome, 2017). SOA differs from CC in that SOA delivers web services between applications, whereas CC delivers software services between end-users and running code (Rittinghouse and Ransome, 2017). SOA reduces the cost of application programming as it allows for reuse of web services (Malik et al., 2018). The concepts of Web Service Description Language (WSDL) and Representational State Transfer (REST) protocol used in SOA are utilised to describe Cloud Application Programming Interfaces (API) (Dillon et al., 2010).

SOA benefit Cloud computing through service description for Cloud services by making use of WSDL and REST, service discovery for Cloud services, service composition for Cloud services and service management for Cloud service (Dillon et al., 2010). CC makes use of similar concepts as SOA, for example, service reusability alike to the CC service being used by multiple organisations, and loose coupling which provides an abstraction layer of service implementation details similar to SaaS (Letaifa et al., 2010). Linthicum (2009) states that organisations should not try to separate CC from SOA and that the best way for organisations' drive towards CC is to leverage SOA approaches.

CC does not replace SOA, CC adds SOA technology in the CC service offering. The concept of sharing computing resources in CC is the same as the sharing of Web Services in SOA. CC computing resources that are not in use can be used by another system. A CC system that requires more resources can obtain additional resources without the need for physical resource allocation. These CC resources are offered on demand similar to SOA.

2.5.3 Grid Computing

Grid Computing (GC) refers to the cooperation of processors from multiple computers to service applications that require high CPU (Hashemi and Bardsiri, 2012). Both CC and GC aim to achieve resource virtualization (Dillon et al., 2010). Similar to CC, GC offers distributed computing that spans across multiple virtual organisations which allows federated sharing of computer resources (Foster et al., 2008). The strategy used in GC to share resources is by making use of middleware applications that distribute a program amongst several computers (Sadashiv and Kumar, 2011). GC allows multiple computers to be combined quickly and to disappear quickly once they have completed their task (Sadashiv and Kumar, 2011). Quick and rapid deployment of systems and applications is the premise of CC, as relates to rapid elasticity and resource pooling (Section 2.4).

GC and SOA are the predecessors of CC. These technologies are now employed in CC in addition to the specific utilisation that CC offers. CC is making use of both GC and SOA within the CC paradigm. SOA and GC are the foundations of CC as they provide the fundamental means to set up a CC network and technology. There are various practitioners as well as scholars who have assisted in the development of CC discovery. The sections below offer more details on CC and its origins.

2.6 Cloud Stakeholders

Martson et al., (2011) identified four types of stakeholders in the Cloud; namely, consumers, service providers, enablers and regulators. Service providers own the Cloud and operate the Cloud by performing maintenance and upgrades to the software and hardware in the Cloud (Martson et al., 2011). Consumers are the Cloud subscribers who use computing services on an operational expense basis (Martson et al., 2011). Enablers bridge the gap between Cloud service providers and consumers by providing additional capabilities such as Cloud monitoring software and platform migration software (Martson et al., 2011). Regulators are national and international regulatory bodies that take the role of arbiter in debates that involve the Internet and its use (Martson et al., 2011). The number of Cloud stakeholders and multiple services make CC more complex to manage, compared to traditional information technologies (Jaatun et al., 2016). There is a continuous dialogue between Cloud stakeholders to ensure that there is trust in the systems that are migrated to the Cloud (Pearson, 2013).

2.7 Organisational Benefits of Cloud Computing

There are various benefits for an organisation to migrate on-premise applications to the Cloud. The following section covers the benefits that CC can provide to organisations. This is, however, not an exclusive list of Cloud benefits due to CC's continuous evolution as new Cloud services are being introduced regularly.

2.7.1 Cost Benefit

The cost benefit of adopting Cloud is amongst the top four reasons why organisations are looking to migrate their applications to the Cloud (Narasimhan and Nichols, 2011). Weinman (2016) argues that it is impractical to assume that Cloud solutions can offer cost savings all the time. Weinman (2016) states that it implies that CSP can also benefit from using other CSP services, for example, Google could use Amazon AWS and Amazon could use Google Cloud and both organisations would save on computing costs. Client organisations are seeing CC as a solution to innovation and business growth (Narasimhan and Nichols, 2011). There are several IT organisations like Zynga and Instagram that moved from CSPs data centres to their internal IT data centres to save on costs (Weinman, 2016).

2.7.2 Mobility

Mobility refers to the ability to work in settings where people interact through digital infrastructures and mobile tools, thus allowing people to execute work anywhere and at any time (Chatterjee et al., 2017). With Cloud computing, computer services are available from

almost any location in the world provided there is internet access, thereby allowing Cloud users to share information in real-time without being in the office (BCS, 2012). Organisations have the advantage that employees working from various locations can still access computing services and carry out the work required (Bassett, 2015).

2.7.3 Service Availability

Service availability is the probability that a system is operational and that the system users are receiving proper service at any given time (Ghosh et al., 2014). There is an increase in the number of computing services that are deployed in the Cloud leading to a corresponding increase in organisations' dependence on Cloud services. This increase in dependency on Cloud services requires the Cloud service to be made highly available (Hu et al., 2014). Data centres providing Cloud services should therefore be designed to guarantee a certain level of availability to client organisations using the Cloud service (Ghosh et al., 2014). Client organisations consequently consider migrating to the Cloud since CSPs have proved to be more dependable compared to on-premise IT infrastructure (Jadeja and Modi, 2012).

CSPs have designed their data centres to provide a higher level of availability compared to traditional IT infrastructure. CPSs are also able to trace and rectify hardware problems easily, thereby simplifying the troubleshooting process and the recovery of systems (Young, 2015). However, regardless of the CSP's drive to ensure a high level of availability, CSPs also experience outages at their data centres, for example, in 2009, Google and Amazon experienced major outages on their Gmail and EC2 platforms (Jadeja and Modi, 2012). In August 2012, users frequently experienced no availability of files and long synchronisation delays on the Dropbox platform (Serrano et al., 2016). Amazon experienced an outage in April 2011 within the AWS Cloud platform, which caused service build on AWS to be inaccessible (Li et al., 2013).

The availability of services directly impacts the quality of service (QoS). QoS is defined as the ability of a service to meet the requirements of services like performance, availability, reliability or cost (Serrano et al., 2016). To guarantee a specified level of QoS, the consumer and CPS have to negotiate a Service Level Agreement (SLA) which will state the values of QoS metrics and the penalties to be applied if the objectives are not met (Ghahramani et al., 2017). An SLA is a contract agreement between a client organisation and the CSP that directs the CPS's efforts to ensure a high level of system availability (Kim, 2009).

2.7.4 Resource Scalability

Resource scalability presents Cloud resources as infinite computing resources being made available on demand (Ardagna et al., 2012). Resource elasticity is a characteristic of CC that enables applications to handle resource demand fluctuations, thus providing resource scalability on demand (Fokaefs et al., 2016). Resources such as memory, CPU and storage can scale up easily on demand to match an increase in demand; the supplier will in exchange increase the monthly payment by the customer to match the resources utilised (BCS, 2012). Scalability allows organisational business agility enabling the business to rapidly deploy new solutions (Marston et al., 2011). Computing resources are readily available, allowing the organisation to quickly set up new systems as required. For example, Netflix moved its workload to the Amazon Cloud in 2010 to focus its efforts on its core competencies, thus leaving Amazon to focus on the infrastructure (Kavis, 2014). This move allowed Netflix to leverage the Cloud's on-demand resources by scaling when required, thereby reducing costs and downtime.

2.7.5 Maintenance and Support

Software maintenance and support is the process of modifying software to correct faults, improve certain attributes, and add enhancements and extensions (Savage et al., 2017). The functions of service upgrades and backups are handled by the CSP without the organisation using the Cloud or having to visit the data centre (BCS, 2012). This allows the client organisation to focus on tasks relevant to the organisation without having to worry about managing hardware and keeping infrastructure up to date.

2.7.6 Business Agility

Business agility is the ability of an organisation to adapt promptly, efficiently and sustainably in a changing environment (Mungwini, 2018; Hirzalla, 2010). Organisations can achieve business agility since the Cloud offers rapid application deployment and so allow organisations to quickly deploy new services. Organisational agility consists of partnering agility (Liu et al., 2016). Partnering agility reflects the organisational agility of interfirm partnerships which allow an organisation to adapt and quickly identify appropriate partners or modify existing partnerships (Liu et al., 2016). The agility of an organisation will depend on the partners the organisation works with such as CSPs. The agility of CC provided by rapid

application deployment can provide an organisation with agility enabling the organisation to quickly respond to market changes, thus remaining sustainable. Narasimhan and Nichols (2011) found that the value of business agility is bigger than the cost benefit of adopting the Cloud. Client organisations looking to migrate applications to the Cloud are now seeing that there is more value in revenue growth than in cost-cutting (Narasimhan and Nichols, 2011). Client organisations are therefore looking at Cloud solutions for growth.

2.8 Cloud Computing Challenges

CC is not without challenges. The major challenges with CC are *interoperability, availability, security, privacy, data protection, business continuity, statutory and legal compliance, lack of standardisation, and network latency issues* that may reduce data transfer speed (Conway et al., 2017; Bassett, 2015). There is a need to address the challenges relating to CC before client organisations can have the confidence to migrate their applications to the Cloud. Furthermore, there are still challenges that are not widely published which indicates that more research is required to simplify the migration to the Cloud. This challenges are *legal, regulatory, compliance, as well as the impact of the Cloud on the client organisation* (Abeywickrama and Rosca, 2015). The legal, regulatory and compliance challenges affect highly regulated environments with regard to data protection. For example, legislation may require that the client organisation's data be kept within the borders of the country where the client organisation operates. Cloud impact on client organisations will determine if the client organisation derives the benefits sought by migrating to the Cloud. More focus is required to address the less published challenges for Cloud migration because this will help simplify the Cloud migration decision for client organisations.

The more widely published Cloud challenges that will be discussed in this section are: *Cloud standards, business continuity and availability, interoperability, vendor lock-in, and dependability on CSP.* These have been selected since addressing them will simplify the Cloud migration decision.

2.8.1 Cloud Standards

The Cloud standardisation effort is an on-going activity. There are various standard bodies and each address different deployment models of CC as listed in Table 2.1 below.

Table 2.1: Summary of Cloud Standards

Standard	Focus Areas	Reference
Distributed Management Task Force (DTMF)	Virtualization Management Initiative (VMAN) Standardised Approaches To Virtual Machines	(Rittinghouse & Ransome, 2009)
Open Cloud Consortium (OCC)	Interoperability Wide Area Clouds Information Sharing Between Clouds Security Architectures	(Rittinghouse & Ransome, 2009)
International Organisation Standardisation (ISO) Distributed Platforms and Services (DAPS)	Migration Between Different Clouds	(Shoniwa, 2016).
ISO/IEC standard 19086-1:2016	Service Level Agreements	(ISO, 2016)
ISO/IEC standard 17788:2014	Taxonomy	(ISO, 2014).
ISO/IEC 17789:2014	CC Reference Architecture	(ISO, 2014).

2.8.2 Business Continuity and Availability

The customer depends on the Cloud service provider for day-to-day access to the IT systems as well as for support and maintenance. Business continuity and availability is important to client organisations, hence client organisations are adopting CC by taking business continuity into account (Opara-Martins et al., 2014). If the CSP experiences an outage then the client organisation could be left without access to business-critical systems (BCS, 2012). The CSP can be attacked by malicious code such as Distributed Denial of Service (DDoS) attacks that render Cloud data inaccessible, compromised or lost (Bassett, 2015). In such cases, there is no regulated process for how the CSP will return data and services to the client organisation (Bassett, 2015). Client organisations must therefore draw up their own contingencies to guarantee the continuation of business operations (Bassett, 2015).

2.8.3 Interoperability

An area of Cloud migration that creates a barrier for migration is Cloud interoperability (Dillon et al., 2010). Lewis (2013) defines Cloud interoperability as the ability to easily migrate workload and data from one CSP to another or between private and public Clouds. In some instances, an organisation would need to integrate on-premise applications with SaaS service to meet business needs (Dowell et al., 2011). The lack of Cloud interoperability causes fear of vendor lock-in (Lewis, 2013). Vendor lock-in refers to a situation where an organisation is unable to change CSP or when the change to another CSP can only be performed at great cost (Armbrust et al., 2010). There is a need for Cloud interoperability since the lack of interoperability prevents organisations from moving their entire IT infrastructure to a new Cloud provider, to change Cloud providers, or to move across boundaries (Kaur et al., 2017).

2.8.4 Vendor Lock-In

CSPs provide enterprise proprietary Cloud-based services, specific technology solutions, APIs and programming languages specific to the CPS, thereby locking consumers into the Cloud (Di Martino et al., 2014). Cloud consumers are then unable to switch from one Cloud to another Cloud and even when possible, this comes at a substantial cost (Opara-Martins, 2014). In a situation where the CSP is experiencing an outage, the consumer will not be able to migrate to another CSP until the CSP is back online (Satzger et al., 2013).

Quint and Kratzke (2016) developed a system called C4S that is designed to eliminate vendor lock-in by making use of “containers”. Containers are lightweight virtualization solutions that provide application deployment without the need for virtual machines (Martin et al., 2018). Another option to prevent vendor lock-in is provided by Quint and Kratzke (2016); the authors state that vendor lock-in can be eliminated by designing a generic Cloud service description language that will define secure, transferable, and elastic services that can be deployed to any IaaS. C4S is still under development and has not yet resolved vendor lock-in.

2.8.5 Dependency on Cloud Service Provider

The nature of migrating to Cloud computing is that client organisations lose and surrender control of their IT systems to CSPs (Hayes, 2008; Alosaimi, et al., 2016). Client organisations lose control of the IT systems as their computing services are completely managed and delivered by a third party (Alosaimi, et al., 2016). The client organisation is dependent on the CSP for day-to-day access to the IT systems as well as for support and maintenance. If the CSP experiences an outage, the client organisation could be left without access to business-critical systems (BCS, 2012).

The area of control that client organisations are concerned about is performance monitoring, that the consumer might simply have to accept the service performance that the Cloud provider delivers, since consumers have no way of monitoring user response time (Hugos and Hulitzky, 2010). The authors state that this problem is temporary since companies (like Akamai, Cisco Systems, F5, IBM, Nimsoft and others) are working with Cloud service providers to enable in-house IT staff to respond to performance issues in the Cloud.

2.8.6 Concerns for Migrating to the Cloud

Organisations are reluctant to move their core applications to the Cloud to avoid the risk of uncertainty with Cloud computing. The areas of uncertainty associated with Cloud computing are: the risk of *data security and privacy, reliability, security, Quality of Service (QoS), performance stability, and cost efficiency* (Hasselbring, 2010; Tchernykh et al., 2019). According to Jones et al. (2019), client organisations experience uncertainty around C*loud standards, Cloud certification, data protection, interoperability, lock-in, and legal certainty*. Researchers have varying lists of challenges and risks for migrating an application to the Cloud which further demonstrates that there is still more research required for client organisations to be comfortable with migrating applications to the Cloud.

Regarding applicability, Cloud solutions are proprietary and limited to certain CSPs and therefore not generic (Hasselbring, 2010). For example, some applications might not be eligible for Cloud migration. Gerber (2018) states that not all applications are suited to the Cloud since an organisation might be running resource-intensive applications on mainframes and those applications will be more expensive to run on the Cloud. Applications in the Cloud also have a dependency on third-party applications that might not be able to run on the Cloud, depending on the application vendor (Gerber, 2018). Reengineering the application to be

compatible with the Cloud might be time-consuming, resulting in higher costs for the consumer (Hasselbring, 2010). The simplification of deploying applications on the Cloud can be achieved by automating the process of the building, testing and deployment of applications (Gerber, 2018). Automation ensures that the process of migrating applications to the Cloud is reliable and repeatable (Gerber, 2018).

Alkhalil et al., (2016) highlighted that customers' lack of Cloud knowledge is considered the biggest deterrent to client organisations migrating to the Cloud. The way services are managed in the Cloud is just as important as migrating services to the Cloud (Repschlaeger et al., 2012). Jamshidi et al., (2015) stated that concerns for Cloud migration are the availability of service, Cloud management, scalability and application resiliency. It is not clear if the concerns are inhibitors or drivers of Cloud migration, for example, regarding availability, the authors state that "Cloud environments typically guarantee a minimum availability" (Jamshidi et al., 2015: p3). However, this contrasts with the Cloud value proposition which promises higher uptime. Cloud services promise a higher level of availability compared to in-house IT infrastructure. For example, Amazon guarantees availability of 99,95% for their EC2 offering and 99,9% for S3, respectively (Basset, 2012). Gerber (2018) states that the knowledge of applications and application dependencies is the biggest challenge in migrating to the Cloud.

Cloud challenges do not stop organisations from migrating to the Cloud. Some of the challenges that are already being addressed are CC standards, for example, security, virtual machine migration, interoperability, and mobility (Lynn et al., 2018). Organisations considering Cloud migration should consider the benefits as well as the challenges of migration to make a decision that is beneficial to the organisation (Lynn et al., 2018). There are well-established technology adoption frameworks that have been researched for Cloud adoption, however, client organisations fail to utilise these due to the frameworks' lack of a universal approach (Lynn et al., 2018).

2.8.7 Cloud Migration Strategies

The client organisation's intent for the migration must be clear and must be for implied business and IT goals (Gartner, 2011). Migrating applications to the Cloud therefore requires that client organisations first understand the business and technical reasons for such migration (Cisco, 2010). By considering the migration approaches of Cisco (2010) and Gartner (2011), the decision to migrate to Cloud computing will not only be based on financial gains but also

on other factors that involve business requirements, Cloud solution providers, and IT architecture and goals. The decision to migrate to Cloud is a business-driven decision that involves organisational risks and is therefore of a wider scope than just its technical aspects (Alkhalil et al., 2016). The analysis and evaluation of potential service providers, Cloud capabilities, guiding principles, services offered, and their potential should be performed long before deciding to migrate to the Cloud (Alkhalil et al., 2016). Jamshidi (2013) states that there is no single solution to the problem of migrating to the Cloud. Other factors that should be considered before migration to the Cloud are Cloud benefits, risks, costs, organisational and socio-technical factors, meaningful prerequisites, financial and legal considerations, culture shifts, etc. (Zhao and Zhou, 2015).

Pahl et al. (2013) and Cisco (2010) states that migration to the Cloud should be considered for each Cloud deployment model Iaas, Paas and Saas as each deployment model has different characteristics. These applications will differ in terms of replaceability and usage within the organisation. Gartner (2011) proposes five options for migrating to the Cloud, namely, *Rehost on Iaas, Refactor for Paas, Revise for Iaas or Paas, and Replace with Saas*. Rehosting is the process of migrating the infrastructure to the Cloud and has the advantage that the application can be quickly migrated to the Cloud with minimal changes Gartner (2011). The disadvantage of not making changes results in the application not benefiting from Cloud characteristics like scalability. Refactoring, also referred to as re-architecting or redesigning by Jamshidi et al. (2015), moves the development environment to the Cloud to PaaS and also have advantages and disadvantages. The advantage of PaaS is that the organisation can keep and reuse some of the development components but organisations should be aware of possible vendor lock-in as some tools have dependencies on specific Cloud platforms Gartner (2011).

Revising the application is the process whereby code is modified to make the application compatible and suitable for Cloud migration but this process can be time-consuming. Revising is more suitable for legacy applications that have to be rewritten for the Cloud Gartner (2011). Rebuilding the application on the new platform discards the old code but vendor lock-in is the main disadvantage to consider, given that the tools used to develop the solution might only be suitable for the Cloud service provider infrastructure Gartner (2011). Replacing with Saas is the process of replacing a current application with a commercially available application in the Cloud but there might be a need to migrate data onto the new application in the Cloud (Cisco, 2010).

Re-engineering software to be compatible with the Cloud often requires the architectural model of the current software to be developed to understand the internal structure of the software, since understanding the internal structure of the software is often insufficient (Frey and Hasselbring, 2010). The migration approaches by Path et al. (2013), Gartner (2011) and Cisco (2010) are similar in that they all consider migration in all deployment models (Iaas, Paas and Saas) although they put little focus on the business aspects such as organisational goals, available budget, resources, and time needed to complete the project (Jamshidi, 2013). Furthermore, an organisation that is planning on migrating applications to the Cloud must consider which approach will best suit its migration efforts.

2.8.8 Deciding Which Applications to Migrate to the Cloud

Organisations have various applications serving different functions. The functions may be finance, human resource, IT, or marketing, but each department will have application service-specific functions. An organisation has to select which application will fit into the Cloud environment (Panori et al., 2016). McDonald (2010) states that an organisation can start with smaller applications to experiment with the process and later migrate the rest of the application stack – once they have gained comfort with the Cloud. By following this approach, an organisation can ensure that the Cloud is tested before moving business-critical systems to the Cloud. Alkhalil et al. (2016) found existing frameworks based on Cloud migration to be lacking in terms of assessing business processes, applications and analysis of the chosen Cloud service.

Furthermore, the varied approaches to Cloud computing migration present challenges for Cloud migration, for example, there is no guidance on which approach to use and under what circumstances; the approaches are not specific to an industry; there are no clear guidelines on choosing which applications should be migrated to the Cloud; and the drivers for migrating to the Cloud are not clear. Although there are various methods to Cloud migration, there is a silo approach to Cloud migration, depending on which approach to follow. The academic and practitioner communities have varied approaches to migration – a unified migration approach does not exist.

2.9 Problem Description

***PD**: There is no uniform approach for migrating on-premise applications to the Cloud.*

The purpose of this dissertation is to develop a framework for migrating on-premise applications to the Cloud by taking into account existing approaches and creating a coherent migration approach.

A universal approach to Cloud migration will be achieved when the proposed solution meets the following solution criteria:

- **SC1** - Provide clear selection criteria for applications to be migrated to the Cloud
- **SC2** - Provide clear motivation and drivers for migration intent
- **SC3** - Create clear guidelines to select the appropriate migration approach, based on the application
- **SC4** - The framework should apply to organisations in any industry of any size

Below are the design objectives:

- To study the selection criteria of applications applicable for Cloud migration
- To assess organisational drivers and motivation for Cloud migration
- To study approaches to migrate on-premise applications to the Cloud
- To develop a uniform framework for migrating on-premise applications to the Cloud

For the solution to provide a universal approach to Cloud migration, a Cloud migration decision framework is being proposed. The framework will be designed to meet the SC stipulated above by providing a universal approach to migrating on-premise applications to the Cloud. The design of the framework is discussed in detail in Chapter 4, the evaluation strategy of the framework is discussed in Chapter 3, the data collection and evaluation of the results of the framework is discussed in Chapter 5.

2.10 Chapter Summary

The chapter provided an overview of CC by first outlining the concept of CC and its characteristics. The definition of CC by NIST provided a lot of the known characteristics of CC and has therefore been used to explain CC, its characteristics, benefits and challenges. Organisations that are considering migrating their on-premise applications to the Cloud do so to benefit from the advantages that the Cloud offers, however, client organisations have to

take into consideration that the Cloud is not without challenges. The CC challenges were discussed since they present barriers to client organisations for migrating to the Cloud. The chapter discussed concerns for Cloud migration, migration strategies and approaches for the selection of suitable applications for the Cloud.

By understanding the benefits and challenges of CC, client organisations can make an informed decision on how to approach migration to the Cloud. The concerns for Cloud migration and the various migration strategies led to the problem description, which states that *there is no uniform approach for migrating on-premise applications to the Cloud.* Along with the problem description, the solution criteria were identified and will have to be addressed to solve the problem description. The design objectives were also highlighted as they will have to be researched to provide solutions for each of the solution criteria. The rest of this dissertation is focused on how to solve the research problem.

CHAPTER 3 - RESEARCH STRATEGY

3.1 Introduction

The research problem has been outlined in the previous chapter. This chapter discuses the research strategy that will be followed in this dissertation. The research strategy will provide a detailed description of the steps that have been followed to conduct the research. By following the research strategy applied in this dissertation, it will be possible for researchers to replicate the research.

This chapter is structured as follows. The first part of the chapter is a reminder of the problem statement that this dissertation is reporting on. Thereafter, an overview of the research strategy is presented. A comprehensive description of the research strategy is then set out, highlighting each "stem" of the strategy. The chapter will conclude with a chapter summary.

3.2 Overview of the Research Problem

The research problem in this dissertation is:

> *There is no universal approach to migrating client organisations' on-premise applications to the Cloud.*

This problem description is discussed in detail in Section 2.12 and labelled Problem Description (PB).

3.3 Research Design Methodology

The research strategy that is followed in response to the research problem is based on the Design Science Research (DSR) method published by Vaishnavi, Keuchler and Petter (Vaishnavi et al., 2019). The primary activities described in DSR focus on the creation of knowledge through the design of artefacts and the analysis of artefacts' use (Vaishnavi et al., 2019). Table 3.1 shows the research process that will be followed.

3.3.1 Step 1: Awareness of the Problem

The awareness of a research problem can come from multiple sources, including industry developments or the identification of problems within a reference discipline (Vaishnavi et al., 2019). Chapter 2 provides a literature review on CC migration and the literature review details the problem regarding the lack of a universal approach to Cloud migration. The literature review was conducted by analysing research material from both the academic and

practitioner communities to identify key issues on Cloud computing migration. The research material was obtained from the following sources: University of South Africa *e-library* (UNISA, 2020), and *Google Scholar* (Google, 2020). The UNISA e-learning library and *Google Scholar* were used to source research published in academia. The search keywords used were: Cloud computing migration, Cloud computing adoption, Cloud computing factors, Cloud computing drivers, Cloud computing benefits and Cloud computing challenges.

Table 3.1: Design Science Research Process Model (Vaishnavi et al., 2019)

Steps	**Activity**	**Output**
Step 1	Awareness of the Problem	Research proposal. The lack of a universal approach to Cloud migration of on-premise applications to the Cloud
Step 2	Suggestion	A framework to assist decision-makers in migrating on-premise applications to the Cloud
Step 3	Artefact Design	Framework
Step 4	Artefact Evaluation	Determine the efficacy of the framework in a real-word environment
Step 5	Conclusion	Communicate the research findings to academia

3.3.2 Step 2: Suggestion

The suggestion step describes the development of an IS proposal based on the awareness of the problem (Vaishnavi et al., 2019). This is a creative step wherein a new functionality is envisioned (Vaishnavi et al., 2019). The problem that this dissertation is going to resolve, is the lack of a universal approach to Cloud computing migration from on-premise to the Cloud (see selection 2.12 for the problem statement). The research problem is depicted in Figure 3.1 in the circles labelled A, B, C and D.

In this dissertation, the researcher will build a framework that will provide decision-makers with a uniform approach to Cloud computing migration. The framework will incorporate various Cloud migration approaches found in the literature, to create a uniform and coherent Cloud migration approach. The output of this dissertation will be the framework developed.

3.3.3 Step 3: Artefact Design

This is the approach that will be used to develop the artefact. The artefact will be made up of building blocks. Each building block will be a decision tool to answer a specific question. The building blocks will then be organised in a process flow that will guide the decision-

maker. The building blocks will be organised in phases. The labelling will be similar to Figure 3.1 where the building blocks will be labelled A, B, C and D. The design in this format will allow the application of the framework to start at phase A and end at phase D.

The first building block will be labelled A. This will be the start of the process on the framework. Block A will be based on a literature review to determine if the application is dependent on-premise or if the application will be well suited to the Cloud. The metrics that will be considered are reliability, availability and maintainability. Building block A will provide the reader with a starting point for the application of the artefact. The purpose of building block A will be to address criterion A in Figure 3.1, namely, to select the most suitable application to be considered for migration to the Cloud. This building block will then provide the input for building block B.

Building block B will be designed to determine if there is organisational value in migrating applications to the Cloud. An existing framework for developing and understanding organisational strategy will be chosen from the literature. The purpose of incorporating a framework for developing an organisational strategy is, to use an established framework that will help decision-makers in assessing if migrating to the Cloud is a strategic fit. The first step in designing building block B is to conduct a literature review on a chosen framework for organisational strategy. For this purpose, the Balanced Scorecard (BSC) has been chosen as a tool to determine organisational value.

Building block C will be designed to evaluate the organisation's readiness for the Cloud. The literature review on this building block will focus on the elements that should be considered to determine if the organisation meets the criteria required to migrate to the Cloud. Elements that will be considered are external factors and internal factors pertaining to the organisation. The organisation will be ready once it meets all criteria required for migration.

Building block D will be designed to allow the organisation to migrate varying types of applications to the Cloud. Different types of applications will require different migration methods. The first consideration will be to determine the service model of the application under consideration. Applications will be classified as IaaS, PaaS and SaaS. A migration approach will be provided for each service model. Each service model will have specific criteria to be met to ensure successful migration. Literature review on migration methods will be performed for each service model.

3.3.4 Step 4: Evaluation

The evaluation of the artefact is conducted by adapting the enhanced Framework for Evaluation in Design Science (FEDS) by Venable et al. (2016). FEDS is a suitable framework for the design of evaluation components of Design Science Research (DSR) projects and programmes (Venable et al., 2016). The process of evaluation in DSR is to evaluate the artefact on the artefact's main purpose, the ability of the artefact to solve a problem or make improvements, improvements to the state of technology, the utility of the artefact, the artefact's impact (such as any side issues), and whether or not the artefact works (Venable et al., 2016). This dissertation is intended to improve the decision-making process of migrating on-premise applications to the Cloud. The FEDS framework is the most suitable since it was developed specifically to evaluate DSR artefacts.

A formative evaluation will be used. A formative evaluation is used to improve the characteristics and performance of the evaluand (Venable et al., 2016). The evaluand is the artefact that will be developed in this dissertation. The time of evaluation is *ex ante* which refers to an evaluation method that forecasts in advance, before the artefact has been designed and constructed (Venable et al., 2016). The completed artefact will be evaluated at the end of the dissertation.

The type of evaluation that will be conducted is a naturalistic evaluation which explores the performance of the artefact in a real-life environment (Venable et al., 2016). The naturalistic evaluation will be conducted through an adapted case study. The evaluation strategy that will be followed is the Technical Risk and Efficacy evaluation strategy which is used to rigorously determine the efficacy of an artefact (Venable et al., 2016). The workflow possibilities of the evaluand are the properties that will be evaluated .

3.3.4.1 Data Collection

The data collection method used will be an adaptive case study. The case study is presented using a structured presentation of the HCMDF by employing an exemplar application to present each phase of the HCMDF.

3.3.4.1.1 Adaptive Case Study Process

Case study demonstration will succeed the following steps proposed by (Hancock and Algozzine, 2016), namely, setting the stage, the environment, ethical clearance, and data gathering in the form of interviews.

3.3.4.1.2 Setting the stage

The phenomenon being studied is the application and effectiveness of the artefact as it is applied to decision-making in a business environment. The basic principles of HCMDF will be explained to participants by going through each phase of the HCMDF.

3.3.4.1.3 The environment:

The artefact will be studied at Organisation X's premises. Organisation X often makes Cloud computing adoption decisions, which makes them a good candidate since they have experience with what the artefact aims to solve.

3.3.4.1.4 Data gathering

Data will be collected through questions during interviews after artefact demonstration. Interviews will be recorded on an electronic device like a cellphone or voice recorder to ensure that no information is missed during data analysis.

3.3.4.1.5 Interviews

A series of interview questions were prepared to study the efficacy of the proposed framework in a client organisation. The questions that were asked are open-ended questions to encourage dialogue. In cases where the questions are not clear, there are subquestions to clarify the main question. Participants will be encouraged to answer as much as possible. The questions are linked to the artefact solution criteria. Below are the interview questions that will be asked.

Below is a summary of the Solution Criteria (SC) that the dissertation needs to resolve.

- **SC1** - Provide clear selection criteria for applications to be migrated to the Cloud
- **SC2** - Provide a clear motivation and driver for migration intend
- **SC3** - Create clear guidelines to select the appropriate migration approach, based on the application
- **SC4** - The framework should be applicable to organisations in industries of any size

The evaluation will take this approach. There are already clearly defined SC that the framework will have to meet for the framework to be successful in solving the RP. To evaluate the framework, the SC need to be converted to Evaluation Criteria (EC). These are the criteria that will be used to evaluate the framework in a real-life environment. From the EC, the Interview Questions (IQ) can be developed. The IQ are designed specifically to meet the EC. This process is designed to ensure that the IQ links back to the SC that have been developed.

For clarity and simplification, the EC will be labelled EC1, EC2, EC3 and EC4.

EC1: Applicability in any organisation

- *IQ1.1: Does the HCMDF consider a holistic approach to decisions about Cloud adoption?*
- *IQ1.2: Will you be able to use HCMDF in any Cloud adoption decision?*

EC1 tests if the proposed framework is holistic and can be applied in any organisation. The holistic part of the proposed framework is important to its applicability in various organisations as it is not designed specifically for any industry or field.

EC2: Clear motivation and drivers for migration

- *IQ2.1: Does the HCMDF consider factors other than cost in the decision-making process?*
- *IQ2.2: Which other factors should be included in the decision-making process?*

EC2 tests if the framework being proposed is considering a broad range of factors in deciding on migrating applications to the Cloud. A positive answer to IQ2 implies that the framework does consider factors other than cost in the decision-making process. Cost is not excluded as a factor in decision-making, however, there are other factors that the client organisation will be presented with in the proposed framework. Question IQ2.1 is a follow-up question that prompts suggestions for the improvement of other factors to be considered.

EC3: Clear application selection for migration

- *IQ3: Does the HCMDF lead to more understanding of the issues involved in decision-making?*

There are various approaches to Cloud migration decision-making. The purpose of EC3 is to test if the framework in its applicability simplifies the decision-making for Cloud migration. The decision-making in Cloud computing as designed in the proposed framework considers every aspect of the framework. A positive answer to this question will also mean that the application selection process is clearly understood by the participants and that the framework is making that process understandable.

EC4: Clear process for selection of migration strategy

- *IQ4.1: Does the HCMDF provide clear and specific steps to follow?*
- *IQ4.2: Is the HCMDF process to follow straightforward?*

- *IQ4.3: Do you find it easy to apply HCMDF without supervision?*

The following questions were asked to determine any improvements to the artefact. The questions are not to test the efficacy of the framework as that is already addressed by the evaluation questions previously discussed.

- *IQ5.1: Is anything redundant in the HCMDF?*
- *IQ5.2: Which part of HCMDF is not required for decision-making around Cloud adoption?*
- *IQ6.1: What changes to the HCMDF would you suggest?*
- *IQ6.2: Are there other components that need to be added to HCMDF to make it more holistic?*

Considering that the framework will be tested and evaluated for the first time, it is fair to consider that there will be areas of improvement. The last four questions aim for research participants (who have experience in Cloud migration) to provide input that can improve on the framework

3.3.4.1.6 Data Analysis

The data will be analysed in a narrative format. Each interview question will be stated, followed by every answer from the respondents. Each question will be treated separately to conclude whether the artefact has been successful in solving a particular question. After the evaluation of each question, the final result as to whether the proposed framework has managed to solve the problem description stated in Section 1.3 will be presented.

3.3.5 Step 5: Communication

The dissertation will conclude by providing the reader with a reminder of the problem statement, the objectives of the research, and the criteria required to solve the problem. For the problem to be resolved, the solution should meet the criteria identified in Section 2.12. For the research to be complete, it has to meet the research objectives set in Section 2.12. The chapter will summarise how the artefact was evaluated and how the data was collected and evaluated. The researcher will provide evaluation results and how the objectives of the research were reached.

3.4 Ethical Considerations

The organisation and participants where the research will take place will be treated with confidentiality. To protect the identity of the organisation, it will be referred to as Organisation X. To protect the identities of the participants, they will be referred to as participant A, participant B, participant C, participant D, and participant E. A total of five

participants will participate in data gathering. Research participants will be provided with a research participation sheet where confidentiality is guaranteed.

The reliability of the data collected will be proved by its credibility, transferability, dependability and conformity. Credibility will be guaranteed by collecting data from an organisation with a real-world problem to solve. Dependability is guaranteed by designing the data collection instruments in such a way for the data collection to be performed the same way in other organisations. Transferability means the artefact can be applied in any organisation and conformity prevents research bias by storing the data and; data serves as an audit trail which prevents tampering.

The *Consent to Participate in the Study* document is a form that participants fill in and sign to give their consent for taking part in the study. The *Participant Information* sheet informs the participants of the purpose of the research, why they were selected to participate in the study, their right to withdraw from the research, as well as to assure participants of the protection of their privacy and anonymity. The evaluation instrument has been drafted as a manual for participants to follow as they implement each phase of the HCMDF. Hancock and Algozzine (2016) provided practical characteristics for conducting a case study.

A case study identifies topics of interest (Hancock and Algozzine, 2016). The topic of interest in this study is the effectiveness of the application of HCMDF artefacts in a business environment. This researcher will test if the HCMDF is coherent and uniform against the set criteria (see Section 5.1 for criteria to be met). The research process is a systematic series of steps with careful analysis of the case being studied (Hancock and Algozzine, 2016). The presentation of the HCMDF will follow a step-by-step process that discusses each phase of the HCMDF. Each phase of the HCMDF will be discussed in sequence by following presentation notes from the walkthrough document. The presentation is followed by a series of prepared questions that are intended to address the key criteria for the HCMDF to be considered successful in resolving the problem statement.

The duration of information gathering for case study research can take days, weeks or even months (Hancock and Algozzine, 2016). Two weeks were reserved for data collection due to the availability of the participants. Some meetings had to be cancelled due to of some of the participants not being available. Only one participant was not available for data collection and was removed from participating in the research.

The outcome of the research is usually presented in a narrative format (Hancock and Algozzine, 2016). Research outcomes will be discussed in the current chapter. Each participant provided valuable feedback on the HCMDF, therefore the information gathered was analysed to cover each aspect that the participants provided. The outcome will be presented in a narrative format since "open" questions were asked, thus giving participants the opportunity to provide more detail when responding.

3.5 Chapter Summary

In this chapter, the research strategy was outlined. The strategy that will be used is Design Science Research towards producing a research artefact. The design of the artefact that will be produced is discussed in detail in Chapter 4. DSR is a five-step process, namely awareness of the problem, suggestion, development, evaluation and summary. This chapter discussed the contents of each step of DSR in detail – as it applies to this dissertation. In Step 1, awareness of the problem was discerned through the literature review conducted in Chapter 2. Step 2 discussed the potential solution to the research problem and proposed the decision framework. For more details on the proposed solution, see Chapter 4.

Step 3 discussed the design process of the artefact by providing details on how the design will be approached. The design approach that was discussed was the use of building blocks and designing the artefact in phases. This approach was chosen to ensure that each phase can be designed and evaluated as a separate entity. Although the entities are separate, they are joined in the objective of building a universal Cloud migration framework. Each building block was discussed in terms of where the information is collected and how that information is used to construct the building blocks.

Step 4 provided details relating to how the artefact will be evaluated once it is complete. The evaluation process includes data collection, an adaptive case study, and ethical considerations. Furthermore, Step 4 discussed how the data will be evaluated and reported on once collected. The last step of the DSR process is Step 5, which is the conclusion of the chapter. The conclusion of the dissertation will provide evidence that the artefact design solves the problem description, providing a summary of the dissertation and final remarks on the dissertation.

CHAPTER 4 – ARTEFACT DESIGN

4.1 Introduction

The proposed framework is designed to solve this Problem Description (PD): *There is no universal approach for migrating a client organisation's applications to the Cloud*. The problem description is discussed briefly in Chapter 2, Section 2.12. The Cloud migration decision framework is designed to provide client organisations with a decision framework that can be applied to every Cloud migration decision. The output of this chapter is a complete decision framework that will be evaluated in Chapter 5.

This chapter is structured as follows: Section 4.1 provides the design process overview, Section 4.3 discusses the design of building blocks, Section 4.4 will discuss the design of value assessment, Sectin 4.5 will focus on the design of organisational readiness assessment, Section 4.6 discuss how the migration strategy is designed, Section 4.7 combines all the building blocks and the framework is presented. The chapter will conclude with a chapter summary in Section 4.8.

4.2 Design Process Overview

The Solution Criteria (SC) for the dissertation were discussed in Section 1.3. In this chapter, the SC have been converted to Design Criteria (DC). These are the criteria that need to be met for the framework to solve the PD. The DC for the framework are:

- **DC1 -** Clear application selection
- **DC2 -** Business drivers
- **DC3 -** Clear migration selection approach
- **DC4 -** Not industry-specific

The design process takes into consideration that there will be a need for multiple decision points within the framework. These decision points are represented by building blocks that are labelled Phase A, Phase B, Phase C and Phase D. Each Phase is designed to provide the client organisation with the opportunity to evaluate whether or not they should proceed to the

next phase. Each Phase will have an input, a process and an output as depicted in Figure 4.1 below.

The Design Criteria aim to provide information on the "what", "why" and "how" of the decision process. DC1 ensures that the client organisation has a clear process to determine which of their on-premise applications are eligible for Cloud migration. DC1 simplifies the selection process by evaluating each application based on the application's predefined dependability metrics. Section 4.3 discusses the application selection process in more detail.

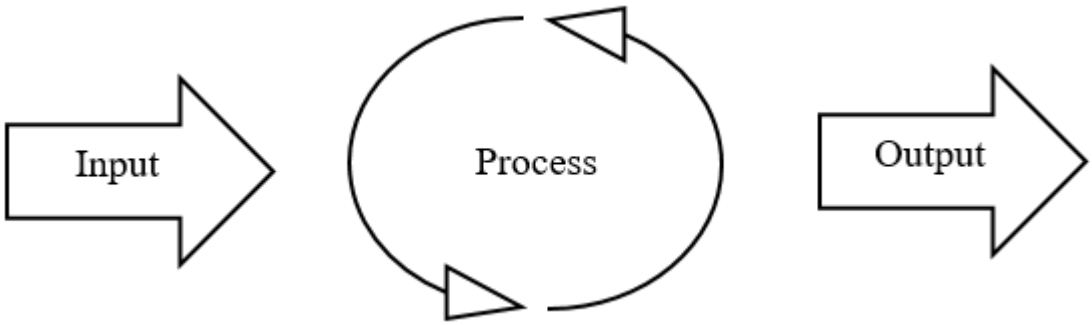

Figure 4.1: Structure of each phase

DC2 provides client organisations with a process to evaluate why the migration to the Cloud is necessary for the client organisation by evaluating the benefits of migration. Different applications will derive varying benefits from migration, therefore DC2 aims to ensure that each application is put through a process where the benefits of migration will be identified.

Different applications will require different migration approaches and the purpose of DC3 is to ensure that the client organisation follows the right migration approach for the specific application. DC4 ensures that the framework applies to any organisation and can be repeated for every migration. The next section discusses each phase in detail.

4.3 Phase A – Dependability Assessment

According to Cisco (2010), a migration approach begins with a process that determines which application is eligible for the Cloud. The objective of starting with application selection is to provide client organisations with a method to evaluate which of their applications would be most suited for the Cloud. The application will be evaluated against set standards and practices within the client organisation. The applications to be considered for migration will be selected from the client organisation's application catalogue. An application catalogue can

be any system that stores a list of applications within the organisation. For Phase A, the input will be the application catalogue.

Figure 4.2: Phase A: Application Selection Process

Once the application has been selected, the application will be evaluated for dependability on the client organisation's data centre. A system that integrates various attributes such as reliability, availability and maintainability is dependable (Stantchev and Schopfer, 2009). The attributes together form a Reliability, Availability and Maintainability (RAM) model in this dissertation. RAM evaluates application dependability based on set targets developed by the client organisation. For these targets to be well written, they should be SMART (Rance, 2013). Table 4.1 provides a breakdown of the SMART acronym.

Table 4.1: SMART Targets (Rance, 2013)

S	Specific	Targets should be clear and straightforward
M	Measurable	It should be possible to determine if the target has been achieved
A	Achievable	The target must be achievable
R	Relevant	The target should contribute to business value
T	Timely	The target should be able to be reported on during the reporting period

Availability is the first requirement to consider for applications and requires that the client organisation understands what it is, what would affect it, and how to calculate it (Rohani and Roosta, 2014). An application that is not available is said to be experiencing downtime, thus downtime is a measure of an application's unavailability (Chege, 2013). The importance of

application availability is its impact on business since downtime results in direct and indirect costs for the client organisation (Chege, 2013). Even the smallest amount of downtime causes significant business costs since users will not be able to use of the application effectively (Molyneaux, 2014). For this evaluation, (in determining which applications are suitable for the Cloud) only applications that experience reduced availability will be considered for Cloud migration. An application should be considered for migration if it experiences more downtime when hosted within the client organisation's data centre. Application availability is based on Agreed Service Time (AST) and downtime (DT) according to the formula Availability = ((AST-DT)/AST) x100 (Rance, 2013) and availability is measured over time (Rohani and Roosta, 2014). Rance (2013) describes AST as the time that the system is supposed to be available and DT as the time when the system is expected to be available but it is not. For example, if AST is 10 hours per day and the system was not available for 2 hours due to outage, then the system has an availability of (10-2)/10 * 100 = 80%. An application that experiences lower AST compared to what the client organisation has defined as their standard is eligible for migration.

The measurement for availability that will be used is AST.

Reliability refers to the system's ability to perform expected operations or tasks (Szkoda, 2014; Rohani and Roosta, 2014; Tan et al., 2011). Application reliability affects end-user experience as it is a user-oriented view of the quality of the application (Farooq et al., 2012). Reliability is measured over a period of time similar to availability (Farooq et al., 2012; Rohani and Roosta, 2014). Therefore, an application that constantly fails is considered less reliable compared to an application that seldom fails (Farooq et al., 2012).

The measurement of an application's reliability is through application performance measurement, therefore, the performance metrics of the application will be considered part of the RAM model (Malkawi, 2013). Molyneaux (2014) identifies two key performance indicators (KPI) for an application, *service-oriented indicators* and *efficiency-oriented indicators*. Service-oriented indicators are directly related to end-user experience and measure how well the application is providing services to end-users; efficiency-oriented indicators measure how the application is making use of the IT infrastructure (Molyneaux, 2014).

Service-oriented indicators are *availability* and *response time*, and efficiency-oriented indicators are *throughput* and *capacity* (Tanuska et al., 2012; Molyneaux, 2014). Availability

has already been discussed in the previous section. The following discussion is limited only to response time, throughput and capacity. Capacity is also not discussed in detail here since it relates to resource capacity, which is discussed in Section 2.4 relating to CC. However, it is important to mention that capacity is also relevant to application dependability since an application that is unavailable due to capacity issues is also considered not dependable.

Response time refers to the time the application takes to respond to end-user requests (Molyneaux, 2014). Throughput is the measure of how much data can be sent across a network and is measured in bits per second (bps) (Kozierok, 2005). A higher network throughput does not necessarily translate into faster application response time since some applications may not be designed to handle high traffic and data volume (Hoxmeier and DiCesare, 2000).

Szkoda (2014) describes maintainability as the system's ability to be restored to an operational state and consists of two components, namely, corrective maintenance and preventative maintenance. When an application is going through maintenance, it is expected to have the service restored within a specific time (Tan et al., 2011). Corrective maintenance refers to bringing the system to an operational state after failure, Preventative maintenance is the act of making system changes to improve its reliability and control (Szkoda, 2014).

In the case of corrective maintenance, the application is still required to become available within a stipulated time and this is referred to as Mean Time To Repair (MTTR) (Rohani and Roosta, 2014). MTTR is an important factor in determining an application's availability (Rohani and Roosa, 2014). Similar to how downtime is calculated, the effect of an application failure due to an unplanned outage will also be measured in downtime. Application Availability, Reliability and Maintainability are highly related since one cannot discuss application maintenance without discussing downtime and one cannot discuss reliability without discussing availability. The attributes of dependability are therefore able to define the key metrics that organisations have to evaluate to determine application dependability. These metrics are tabled in Table 4.1

In Phase A of the framework the RAM model is proposed and aims to provide the client organisation with measurable metrics in determining if their on-premise applications should be migrated to the Cloud. It is proposed that the metrics are collected over a time period requiring the client organisation to have a system in place to track the metrics related to application dependability. Applications that fail the dependability assessment will then be

considered for Cloud migration while applications that pass the dependability assessment will remain on-premise. The objective is to keep the focus on problematic applications that will benefit from the Cloud. The above information on RAM provides a basis of which metrics are required to measure dependability.

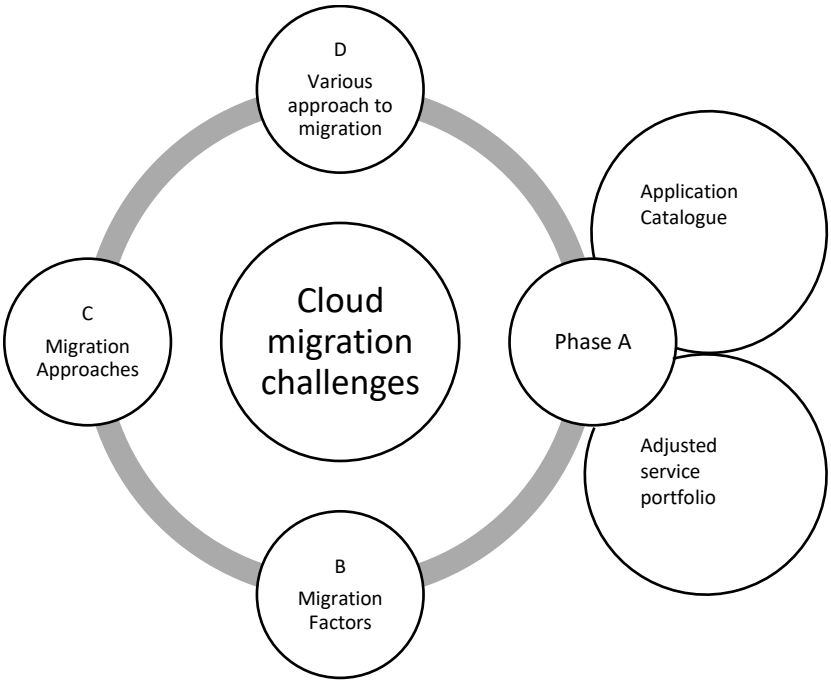

Figure 4.3: Application Selection Process

Every phase of the artefact is being designed to solve the Cloud migration challenges as depictured in Figure 1.1. Phase A is depicted in the application selection portion of Figure 4.2, which is an adaptation of Figure 4.1. The input for Phase A is the application catalogue with the dependability assessment conducted by the RAM model; the output of phase A is the Adjusted Service Portfolio. The remainder of the phases will be conducted in the same format and the end of the section will demonstrate which part of the Cloud migration challenges are being addressed.

4.4 Phase B – Value Assessment

The objective of Phase B is to provide a method for client organisations to evaluate if there is a value in migrating to the Cloud. Sneed (2006) suggests that the process to determine organisational value is best conducted by a business analyst. The first step of the design is to determine the value IT brings to the business. Understanding the value of IT for, business

will provide a starting point in determining the value of migrating an on-premise application to the Cloud. The aim is to provide input to businesses by assisting them in deciding if the migration is worthwhile. With reference to Figure 1.1, this addresses point B on the diagram. The input to Phase B is the adjusted service portfolio which is an output of Phase A. The adjusted service portfolio will be subjected to a value assessment, producing an output called the portfolio of eligible migration services. The value assessment process is depicted in Figure 4.4.

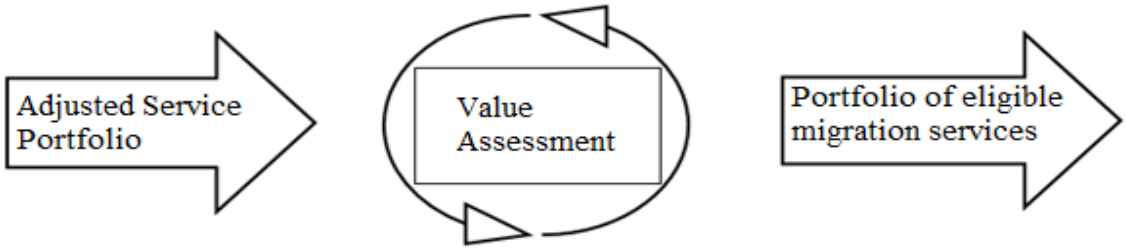

Figure 4.4: Phase B – Value Assessment Process

4.4.1 Understanding the Value of IT to Business

The relationship between IT investment and business value remains unexplained and this topic has been predicted to persist as one of the major topics for IT researchers (Schryen, 2013). The value of IT to organisations depends on internal and external factors such as organisational resources, trading partners, the competitive environment, and the macro environment. However, what precisely is known about how IT contributes to business performance is still uncertain (Schryen, 2013). Schryen (2013) states that when looking at the value of IT investments, one needs to consider the *ex-ante* and *ex-post* nature thereof. Whereas *ex-ante* focuses on answering which of the alternative IT investment(s) available will the best at helping an organisation to reach its goals, *post-ante* looks at what value was created for the organisation by IT Schryen (2013). The link between *ex-ante* and *ex-post* determines whether IT has delivered on what was expected by the organisation. The proposed framework aims to solve this problem by migrating those applications that do not add value to the organisation to the Cloud.

Milis and Mercken (2004) evaluated the most commonly used tools to measure IT investments. They state that traditional measures of IT investments are not impressive and are solely based on financial measures such as the Payback Period (PP), Account Rate of Return (ARR) and Return on Investment (ROI), with the least used tools being Internal Rate of

Return (IRR) and Net Present Value (NPV). Milis and Mercken (2004) also stated that some tools such as PP are not ideal for IT investment due to the length of the investment. IT tends to be long term investment while PP is more applicable to short term investment (Milis and Mercken, 2004). ROI works better than PP as it takes into consideration the complete lifecycle of an investment, however, both PP and ROI do not consider the time value of money – hence NPV and IIR would be preferable (Milis and Mercken, 2004).

Martinsons et al. (1999) state that financial measures are not well-suited to the new generations of IT applications and they propose the Balanced Score Card (BSC) as a tool to help management evaluate IT investments. The BSC is a tool that is used to align business activities to the client organisation's vision and strategy (Grigoroudis et al., 2012). For this study, the BSC was selected as a tool to help client organisations determine the value of IT within the organisation. By understanding the value of IT, the client organisation can apply this value to determine if the IT application still produces the same value on-premise compared to being hosted in the Cloud. The following section will discuss the concept of the BSC and how it will be applied within the proposed framework .

4.4.2 Balanced Scorecard

The Balanced Scorecard (BSC) was developed by Kaplan and Norton (1992) and looks at the organisation from four perspectives. There are three nonfinancial performance measures: learning and growth perspective, internal business processes perspective and financial measure, and one financial measure which is finance perspective. Each perspective delivers a specific purpose (Kaplan and Norton, 1992).

The following measures are adopted from Kaplan and Norton (1996) and summarised to guide how a client organisation should use the BSC to measure and implement its organisational strategy. Every perspective must speak to the organisational strategy, thus adding value to the organisation. The framework is designed in such a way that a Cloud solution that does not add value to the strategy of the client organisation will not be considered.

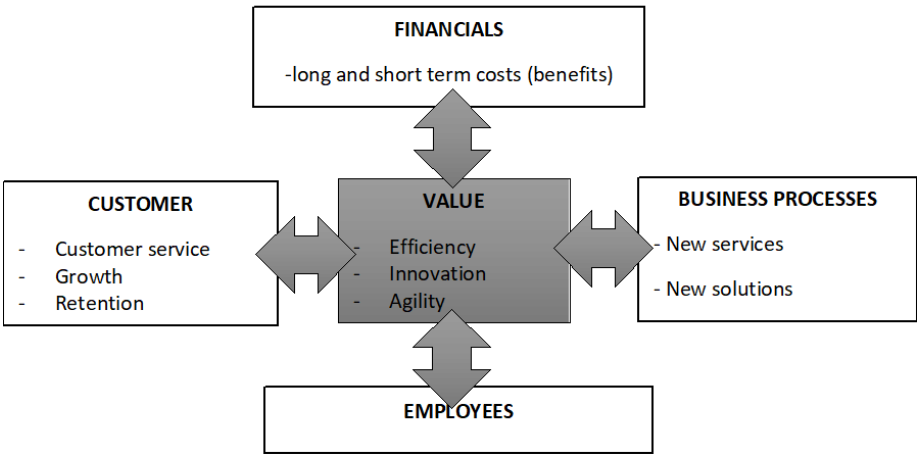

Figure 4.5: The Balanced Scorecard (Kaplan and Norton, 1996)

The application of the BSC is not a blanket approach due to the distinctive characteristics and different strategies of each organisation, therefore, every organisation will have unique performance measures that are best suited for their business performance, as evaluated by its stakeholders (Wongrassamee et al., 2003). Kaplan and Norton (1996) responded to critics of the applicability of the balanced scorecard, based on its focus on financial and non-financial performance data. In their response, the authors stated that, similar to an aircraft that requires different performance measures such as altitude, fuel, and speed; an organisation also requires multiple measures that are both financial and nonfinancial to have a holistic view of how the organisation is performing. It is for this reason that the Balanced Scorecard was selected as instrument to determine business value because it considers both financial and nonfinancial measures, thus providing a holistic view of the organisation.

To implement the Balanced Scorecard to its fullest, the organisation should consider the four perspectives as linked together in cause-and-effect relationships as depicted in Figure 4.5.

Figure 4.6: Cause and Effect of BSC Perspectives (Kaplan and Norton, 1996)

The learning and growth perspective puts the focus on sustaining the organisation's ability to change and improve to achieve its vision (Kaplan, 2009). The internal business process perspective focuses on identifying specific business processes the organisation needs to excel

in to satisfy customers and shareholders (Kaplan, 2009). The customer perspective focuses on how the organisation should appear to its customers to achieve this vision (Kaplan, 2009). The financial perspective focuses on how the organisation should appear to its shareholders to succeed financially (Kaplan, 2009).

4.4.2.1 Financial Perspective

"To succeed financially, how should the organisation appear to its stakeholders?" (Kaplan, 2009, p. 4).

For-profit organisations are focused on the bottom-line, to maximise shareholder value by increasing revenue, whereas nonprofit organisations are concerned with the amount of funding they receive (Martello et al., 2008). The objective of a for-profit organisation is to maximise shareholder value that measures an organisation performance through return on investment (ROI) and for this reason, each investment is driven by reaching this objective (Martello et al., 2008), namely wealth creation. A nonprofit organisation needs to manage cost optimally to ensure the sustainability of their operation (Martello et al., 2008).

Wealth is created when the return on invested capital exceeds the cost of capital (Slater, 1997). Financial value can be calculated using measures that indicate profitability and returns for the shareholders. When putting an application in the Cloud, the framework is being designed to still achieve the objectives of shareholders.

4.4.2.2 Customer perspective

"To achieve organisation vision, how should the organisation appear to its customers?" (Kaplan, 2009, p. 4).

Organisations should determine what customers they want to attract as well as which market segment they will focus on. There should be a good customer-value proposition that focuses on product mix, price, service, relationships and company image (Martello et al., 2008). Nowadays, value is determined by the customer and not the organisation (Li, 2009). An organisation can differentiate itself from competitors by choosing any of these value propositions: operational excellence, customer intimacy, or product leadership (Kaplan and Norton, 2000).

An operational excellence strategy focuses on the approach to the production and delivery of products and services (Treacy and Wiersema, 1993). When an organisation uses a CRM solution for operational excellence, their focus is on cost reduction and process improvements

to raise the quality of customer interaction (Pokharel, 2011). The organisation employs this strategy to differentiate themselves from competitors by making use of a combination of price, quality and ease of purchase (Sulaiman, 2014). These types of organisation continuously innovate and stay ahead of the competition (Sulaiman, 2014).

Organisations use tools like CRM to increase intimacy with the customer, put the focus on knowing the customer, and building a close relationship with the customer (Pokharel, 2011). Organisations that focus on customer intimacy choose who they want for customers, they build relationships with them, and then customise their solutions based on the knowledge of these customers and their preferences (Sulaiman, 2014).

Customer intimacy is an indicator of the relationship between the organisation and the customer and can be viewed from two angles (Liang, 2009). The first angle is from the organisation's perspective, and the second angle is from the psychological perspective of the customer (Liang, 2009). A feeling of "closeness" by the customer towards the organisation will lead to a favourable attitude by the customer. Li (2009) states that an organisation can build customer intimacy by customising their products as well as by building brand loyalty.

Product leadership strategy is about producing state-of-the-art products and services and this requires the organisation to be creative, to commercialize their ideas quickly, and to pursue new solutions to solve issues (that their past solutions solved previously) relentlessly, thereby raising the bar constantly (Treacy and Wiersema, 1993). Organisations implementing this strategy, aim to impress customers with innovative products or services (Sulaiman et al., 2014). High-tech companies always position themselves as product leaders and they do this by being the first to enter the market, thus taking advantage of market share and gaining experience earlier than the competition (Li, 2009). Organisations that come after and copy the innovation will therefore be followers and the standard of the product offering would have already been set up by the product leader. Chapter 2, Section 2.7 discussed the organisational benefits of CC: by leveraging CC, organisations can add value for their customers and increase their revenue.

4.4.2.3 Internal Business Processes perspective

"To satisfy shareholder and customers, what business processes must the organisation excel at?" (Kaplan, 2009, p. 4).

The internal processes perspective determines which processes affect customers. This perspective is concerned with the effectiveness of the entire business system, by considering

the organisation as a system of business processes to create value for the customer (Slater, 1997). Improving internal organisation processes requires that there is a link between strategy and improvements (Martello et al., 2008). The organisational processes should be geared towards delivering on organisational strategy. The proposed framework is designed to assist client organisations in migrating on-premise applications to the Cloud to improve business processes for the customer.

4.4.2.4 Learning and Growth perspective

"To achieve organisation vision, how will the organisation sustain its ability to change and improve?" (Kaplan, 2009, p. 4).

This perspective is about defining the skills, technologies and corporate culture that is needed to support the organisational strategy (Kaplan and Norton, 2000). Employee capability, skills, technology and organisational climate must be aligned to support the organisation's strategy (Martello et al., 2008). The core competencies of learning and growth define three categories of intangible assets necessary for strategy implementation: strategic competencies, strategic technologies and organisational climate (Jelenic, 2011).

Strategic competencies are the necessary skills and knowledge required for employees to support the strategy (Jelenic, 2011). The learning and growth perspective concerns staff – whether staff are able to meet other organisational goals like new product development, continuous improvement, technological leadership and product diversification (Jelenic, 2011). The proposed framework is being designed to ensure that the organisation can continue to improve and create value for itself.

4.4.2.5 Application of BSC within the framework

BSC was selected since it covers a wide area in determining the business value of migration. BSC within the proposed solution will therefore be used to determine value across organisational processes, people, customers and financials. The application of the BSC will have to be performed by specialists within those areas. For example, the financial aspects will require a financial specialist to evaluate the return on investment, customer value will be determined by customer relations, learning and development will be assessed by the human resource department, and business process improvement will be evaluated by business process specialists. Using the BSC to evaluate the application to be migrated ensures that there is business value for the migration intent.

4.5 Phase C: Organisation Readiness Assessment

With reference to Figure1.1, this phase addresses point B. Applications that are eligible for the Cloud can be determined by identifying applications with high expected value and readiness (Kundra, 2011). The output of this phase is an application portfolio grouped in its respective deployment models. This process is shown in Figure 4.6 below.

Figure 4.7: Phase C – Organisation Readiness Process

According to Pahl et al. (2013) and Cisco (2010), by considering the type of migration to be determined per Markov (2010) of re-host (Iaas), refactor (Paas), revise (Iaas or Paas) and replace (Saas). From the literature review in Chapter 2, it was found that to build an application portfolio that considers both business aspects and technical aspects will be beneficial. Kundra (2011) identified that the choice between on-premise and Cloud (from a business perspective) should be based on expected value and readiness.

4.5.1 Expected Value

Expected value depends highly on the organisation and this could be driven by business strategy. Kundra (2011) identifies value as efficiency, business agility, and innovation. A client organisation that is considering migrating to the Cloud will expect to derive value from the migration. Without value, the migration would not be required because it does not change anything for the organisation. The organisational value as described by Kundra (2011) is provided in Table 4.2. Efficiency, business agility and innovation are benefits that organisations can expect from migrating to the Cloud. Cloud benefits have been discussed in Chapter 2, Section 2.7.

Table 4.2: Technological Business Value (Kundra, 2011)

Value	**Considerations**
Efficiency	What efficiency can we derive from the Cloud?

	What about other options: New on-premise solution Upgrade existing system
Business Agility	How quickly can we start to benefit from the solution? Compared to options available: New on-premise solution Upgrade existing system
Innovation	What innovation will a Cloud solution enable?

4.5.2 Readiness

Readiness is a risk-based decision process to ensure that an organisation can successfully migrate their applications to the Cloud as well as ensuring that the CSP can meet organisational needs (Kundra, 2011). Readiness should therefore be conducted internally as well as externally. Complexity and security form part of the readiness for Cloud adoption. Applications that are ready for the Cloud can be migrated "near-term", while applications that are not ready can be migrated at a later stage; strategies should be put in place to modify these applications for them to meet readiness criteria (Kundra, 2011). Loebbecke et al. (2011) introduced a "magic matrices" method for evaluating the Cloud for an organisation, i.e., Continental AG – for an "auto" Cloud readiness assessment. Loebbecke et al. (2011) provide the following metrics for Cloud readiness: relevance to the core business, importance to the business, the complexity or simplicity of the application integration, management and administration of the application, network connectivity, identity management, and compliance with legal requirements. Kauffman et al. (2014) categorise the readiness assessment into four categories: Technology and Performance, Organisation and Strategy, Economics and Valuation, and Regulation and Environment.

Kauffman et al. (2014) provide the context of these categories as follows: Evaluating for Technology and Performance assesses if the Cloud solution is a technology fit with the client organisation's IT and systems. Organisation and Strategy determines if migrating to the Cloud is in line with the client organisation's strategic orientation and capabilities. The Economics and Evaluation considers aspects of the Cloud market and the CSP with regard to product and service costing. The Regulation and Environment categories evaluate the Cloud solution for compliance and environmental uncertainties. From the information provided above, the proposal for the framework considers that there has to be a client organisation Internal

Readiness Assessment and External Readiness Assessment. The proposed solution evaluates Internal Readiness in Table 4.3 and External Readiness in Table 4.4

Table 4.3: Internal Readiness (Kauffman et al., 2014)

Consideration	**Iaas**	**Paas**	**Saas**
Code changes	High	Medium	Low
Security	High	High	High
Bandwidth	High	High	High
Contracts	High	High	High

Table 4.4: External Readiness (Kauffman et al., 2014)

Sector	**Compliance**	**Legislation**	**Frameworks**
Banking	High	High	Low
Government	High	High	Low
SME	High	Moderate	Low

The focus for this part of the design of the artefact is on circle B of the research diagram depicted in Figure 4.3. The input for this process is the Adjusted Service Portfolio, the value assessment is determined through the balanced scorecard, the output of this process is a portfolio of eligible migration services.

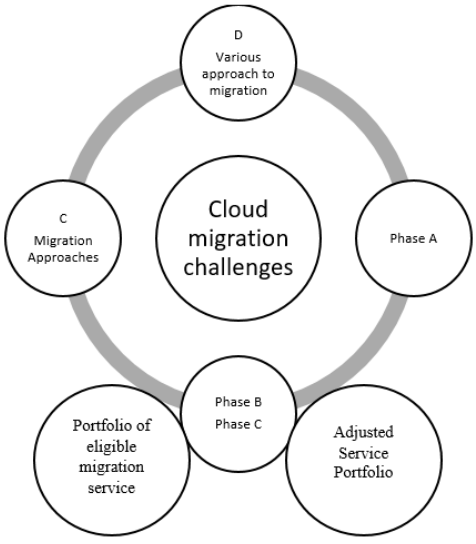

Figure 4.8: Research Problem: Adoption Factors

Section B of Figure 4.3 addresses both Phase B and Phase C of the framework being proposed. The input to section B is the Adjusted Service Portfolio which was determined in Section 4.3, the process is the Value Assessment (Section 4.4) and Organisational Readiness Assessment (Section 4.5), and the output is a Portfolio of Eligible Migration Service. The final part of the design is the Migration approaches which is point C in Figure 4.3

4.6 Phase D: Migration Strategy

The migration approach will depend on the type of application being considered. The next step will be the actual migration of the application. Applications can be classified as either IaaS, PaaS or SaaS. The type of application will determine which Cloud migration strategy should be selected. An input to the migration strategy is the portfolio of services eligible for migration and the output of that is migration documentation. This process is depicted in Figure 4.7

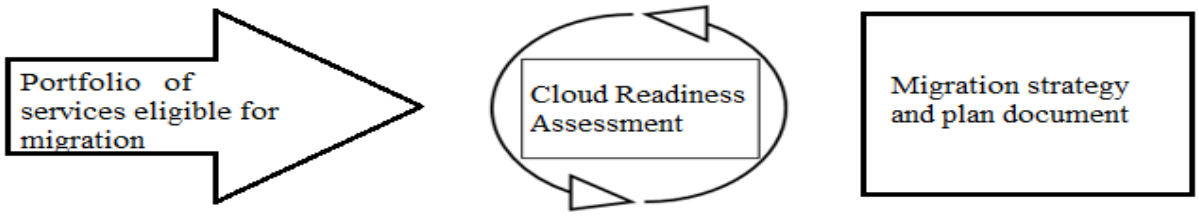

Figure 4.9: Phase D – Cloud Readiness Assessment

4.4.1 Cloud Migration Strategies

The guideline proposed is by Gartner (Stamford, 2011). Stamford (2011) suggests the following five options for migrating to the Cloud: 1) re-host on IaaS, 2) refactor for PaaS, 3) revise for Iaas or PaaS, 4) rebuild on PaaS, and 5) replace with SaaS. Re-hosting on Iaas has the advantage of providing a quick migration since the application architecture does not change and only IT infrastructure configuration is required. The disadvantage of this is that the application does not leverage Cloud benefits like scalability (Stamford, 2011). Re-hosting is suited for legacy systems (Zhao and Zhou, 2014). Refactoring for Paas allows the organisation to run existing applications on the provider's infrastructure with the benefit of backward compatibility, thus allowing developers to reuse the development tools they have invested in (Zhao and Zhou, 2014). With refactoring, the application to be migrated will require minor adjustments thereby preserving the original architecture of the application and reducing adaptation efforts (Zhao and Zhou, 2014). The disadvantage is that some vendors

might only support specific tools that the developers depend on, thereby missing out on certain capabilities and being susceptible to vendor lock-in (Zhao and Zhou, 2014).

Revising the application involves modifying or extending the existing code to support legacy modernization requirements and then rehosting or refactoring the application to the Cloud (Stamford, 2011). Stamford (2011) considers the upfront costs the main disadvantage since expenses will be incurred in an application development project for application modification. Furthermore, the revise option will likely take the longest in delivering capabilities, depending on the scale of the revision. Rebuilding requires the old code to be discarded and the application be "rearchitected" providing organisations with access to the innovative features of the Cloud platform (Stamford, 2011). Vendor lock-in is the main disadvantage of the rebuild option (Stamford, 2011). Gartner's last option is to replace the existing legacy application with a commercial off-the-shelf Cloud solution (Zhao and Zhou, 2014). Inconsistent data semantics, data access and vendor lock-in are the disadvantages of the replace option, however, the advantage is that it avoids investment in application development (Zhao and Zhou, 2014).

Deciding on the type of migration and service to migrate to depends on several factors. The effort required to modify an application to be Cloud-compatible determines whether the migration approach is to rehost to Iaas or to refactor, or to review or replace using Saas. The higher the complexity, the longer it will take to migrate the application to the Cloud. At this stage, the organisation will start drawing up plans on which strategy and approach to use. The migration options are added to Table 4.5.

Table 4.5: Cloud Migration Options (Stamford, 2011)

Re-host on IaaS	Make configuration changes on the application to be hosted on the Cloud Suitable for Legacy applications Ease of modification: Difficult to modify
Refactor for PaaS	Make minor adjustments to application Suitable for: Applications that require backwards compatibly Ease of modification: Moderate
Revise for IaaS or PaaS	Modify existing applications or extend it to for Cloud Suitable for: Applications that Ease of modification: Simple

Rebuild for PaaS	Discard existing application and rebuild a new application on the Cloud Suitable for: Organisation proprietary applications Ease of modification: Simple
Replace with SaaS	Discard existing application and purchase a Cloud-based solution Suitable for: Applications that are available off-the-shelf Ease of modification: Difficult and not worth the effort

4.7 Putting the Framework Together

Until now, the components of the framework being developed have been discussed in isolation. The complete framework is depicted in Figure 4.8. The framework is called the Holistic Cloud Migration Decision Framework (HCMDF). The focus of this step is on building-block D. This building-block synthesizes all that has been discussed thus far in the dissertation by putting together all the building blocks. Figure 4.9 is the HCMDF.

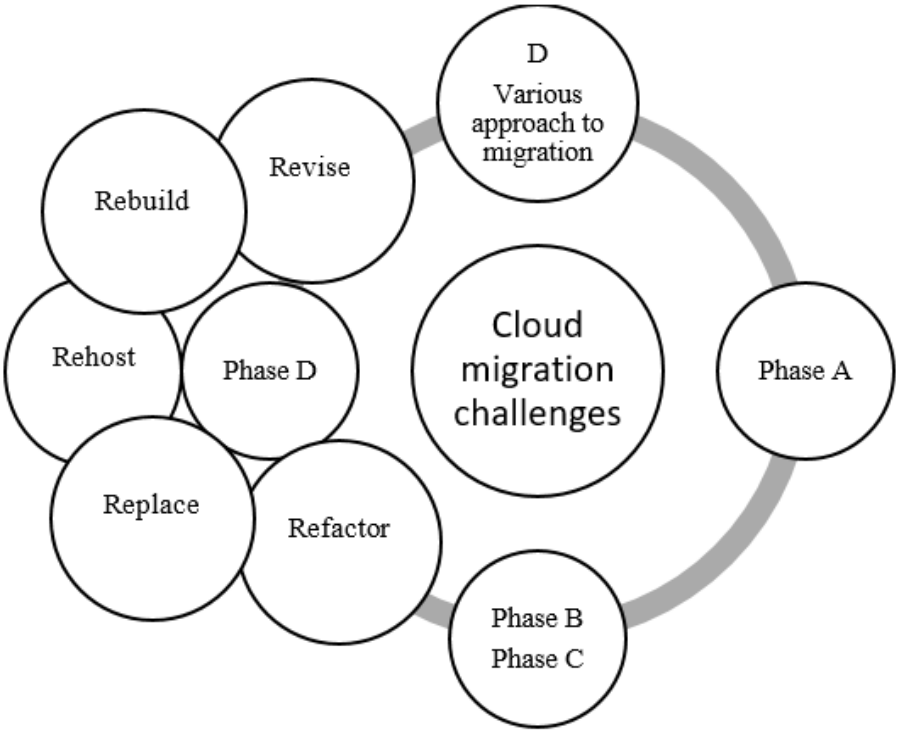

Figure 4.10: Cloud Migration Strategies

How it comes together

In Figure 1.1 (Chapter 1), the challenges of migrating applications to the Cloud were presented. Figure 4.7 below demonstrates how those migration challenges were addressed. The inner circles labelled A, B, C and D identified the Cloud migration challenges as A: Application Selection, B: Adoption Factors, C: Migration Approaches and D: Various Approaches to Migration. Item D is completed only once A, B and C are completed after combining all parts of the framework.

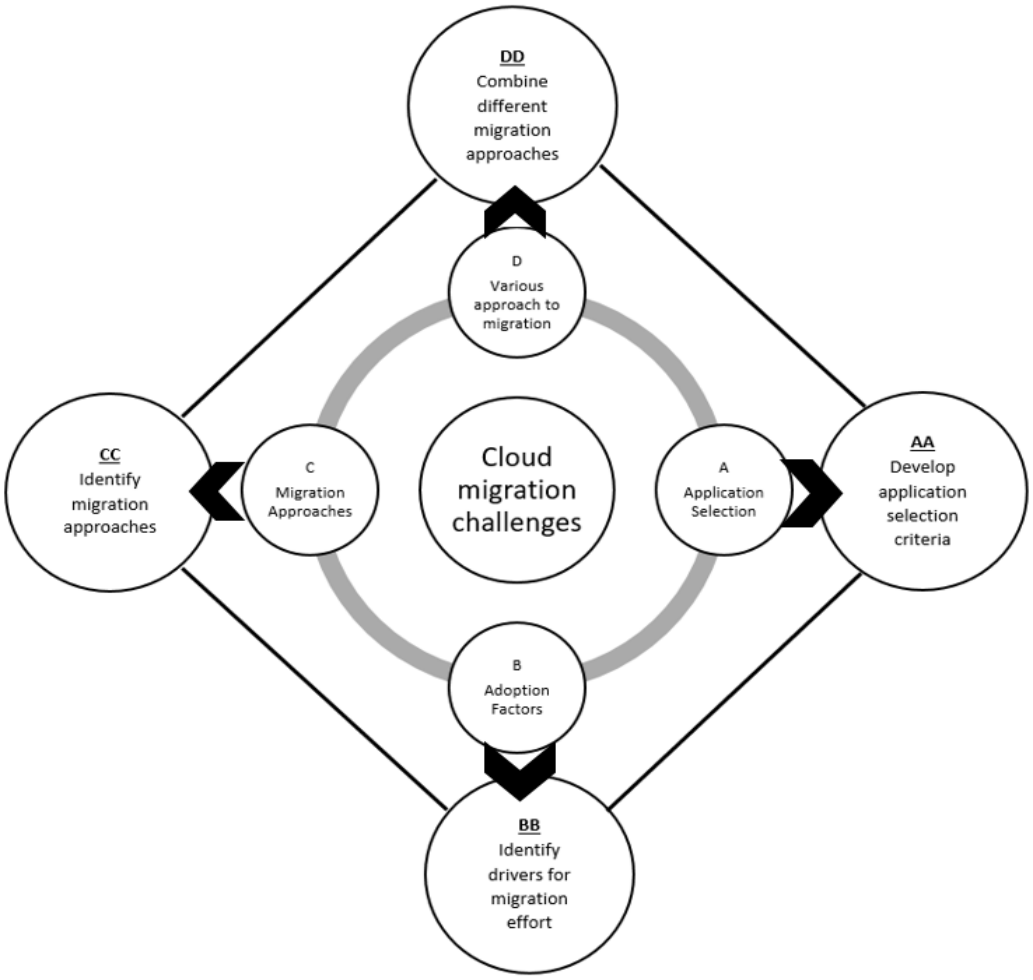

Figure 4.11: The Link Between Migration Challenges and Design Criteria

Figure 4.8 demonstrates the activities required to solve the problem description. In the centre of the diagram are the Cloud migration challenges, the four inner cycles (labelled A, B, C and D) show the four challenges for Cloud migration, and the outer circles (labelled AA, BB, CC and DD) are the design criteria to solve the four inner cycles. The arrow pointing outwards demonstrates the link between the cycles, for example, the challenge in cycle A is addressed by cycle AA. There is a line linking cycles A, B, C and D and similarly, there is another line linking cycles AA, BB, CC and DD. This line linking the cycles, demonstrates that the process is linear and that each of the cycles are linked together. For the final artefact (see Figure 4.9) there are no cycles and this solution is developed into building-blocks, however, Figure 4.8 serves to demonstrate how the building-blocks were developed. The final artefact, the HMCDF, is displayed in Figure 4.9 below.

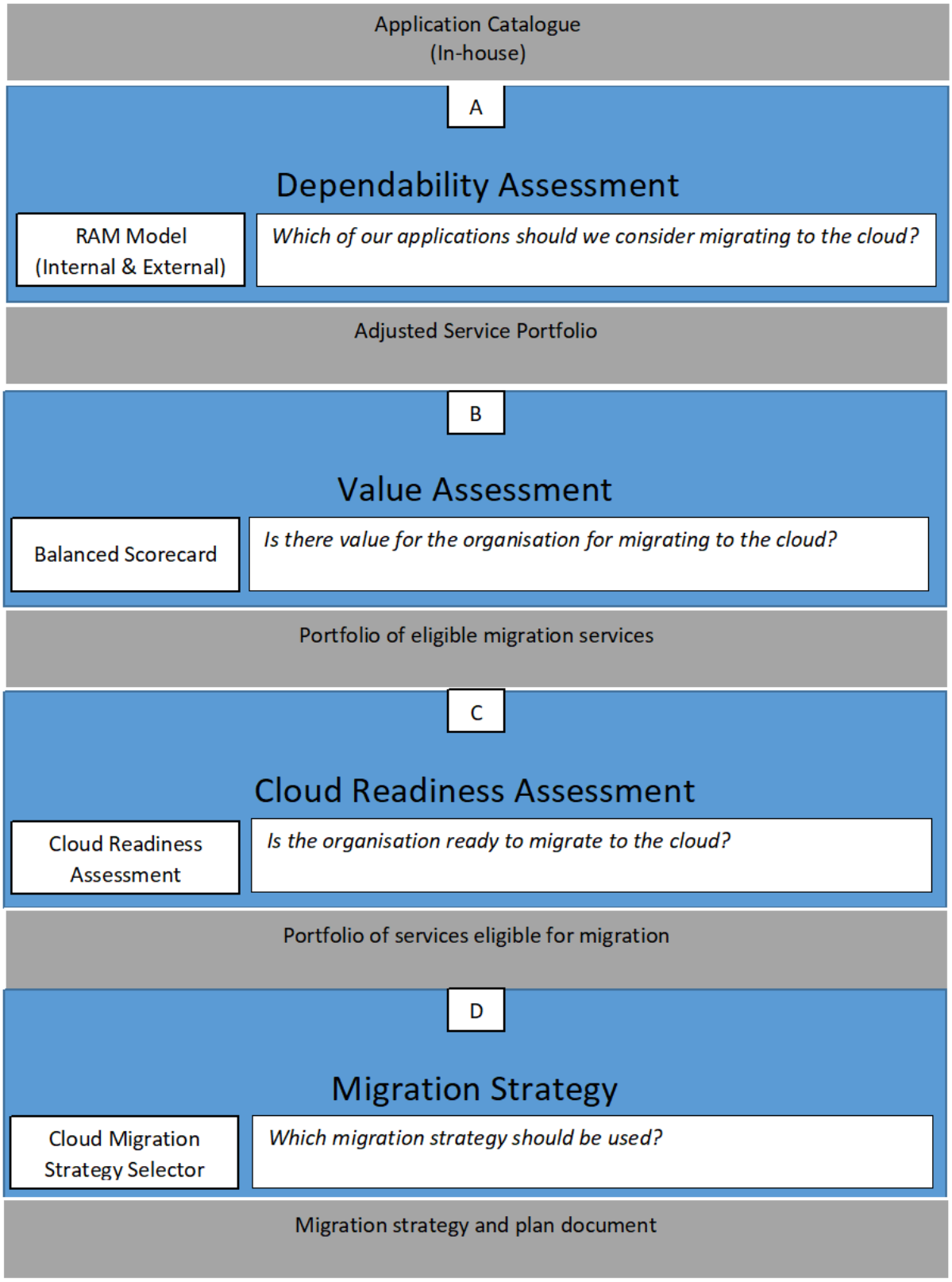

Figure 4.12: Holistic Cloud Migration Decision Framework (HCMDF)

4.8 Chapter Summary

In this chapter, the HCMDF was designed and presented. The chapter outlined the strategy that was used in the design of the HMCDF. From the conceptual point, the design of the framework followed a design where the framework consists of building-blocks that are referred to as phases. A total of four phases were designed to solve the four migration challenges presented in Figure 1.1. The Cloud migration challenges are the application selection method, migration drivers, migration approaches, and applicability to any organisation. Together, when these migration challenges are solved the problem description will be solved.

To solve the migration challenges, the design followed a phased approach where focus was on every migration challenge individually. Phase A was the first challenge to be addressed and served as a starting point for the migration intent. Phase A considered the measurable metrics that are relevant in determining whether the application to be migrated is meeting the operational requirements of the client organisation, by assessing if the application is dependable when hosted on-premise. The aim of Phase A is to prevent the migration of a functioning application to the Cloud with the hope of deriving more value from that application. To ascertain if the application is adding value and operating as expected, Phase A had to be designed to rely on factual data for the evaluation.

Phase B was designed to assess the application performance against business requirements when the application is migrated to the Cloud. This design aims to limit Cloud migration only to applications that will add business value when migrated to the Cloud. A project that migrates an application that will not add value to the organisation will be a wasteful expenditure since there is no justification for the migration. Phase C was designed to determine if the client organisation is ready to migrate their applications to the Cloud. Cloud readiness can be considered in several ways, however, one of the key determinants of Cloud readiness is the assessment of the people within the organisation to determine if they are ready for the Cloud.

Phase D is only considered once it has been ascertained that the application will be more dependable when it is hosted in the Cloud, the business will benefit from the migration and the business will be able to support and work with the application when migrated to the Cloud. This phase is designed to enable client organisations to select the right migration strategy based on the type of application. The final artefact is then presented in Figure 4.9 named a Holistic Cloud Migration Decision Framework.

CHAPTER 5 – ARTEFACT EVALUATION

5.1 Introduction

Chapter four focused on developing the HCMDF to assist organisations' decision-makers in successfully migrating on-premise applications to the Cloud. The purpose of this chapter is to evaluate the proposed framework against the solution criteria (established in Section 1.3) to determine its efficacy in solving the research problem:

There is no universal process for migrating on-premise applications to the Cloud.

The HCMDF was evaluated in an organisation that regularly makes Cloud migration decisions.

Organisations that are considering migrating their on-premise applications have to choose between various migration approaches. The various migration approaches increase the difficulty in the migration process as there are various options to consider. Furthermore, these approaches differ between the practitioner and scholar community. Practitioners offer migration plans for migrating specific applications to their specific Cloud platform, and these approaches might not be suitable for migrating the same application to a different CSP. There is therefore a lack of a universal approach for migrating on-premise applications to the Cloud. The HCMDF is designed to provide a migration methodology that is uniform. To achieve this goal, there are four criteria that the HCMDF need to meet as listed below:

- Provide clear selection criteria for applications to be migrated to the Cloud
- Provide a clear motivation and driver for migration intent
- Provide clear guidelines to assist decision-makers in selecting the appropriate migration method, based on the application being migrated
- The artefact should be applicable to organisations in any industry of any size

This chapter focuses on how the data was collected as well as the analysis of the results.

The remainder of this chapter is structured as follows. Section 5.2 will discuss the evaluation approach that will be used to test the efficacy of the proposed framework, Section 5.3 will introduce the research participants and their background in CC, Section 5.4 explains the

interview schedules, Section 5.5 provides the data that was collected during the interview process, Section 5.6 provides analysis of the results and the chapter will conclude with chapter summary in section 5.7.

5.2 Evaluation Approach

To test the efficacy of the artefact, the HCMDF was evaluated in a real-world setting in an organisation that continually makes Cloud computing decisions. The approach that was used is a three-step process. The first step was to approach the organisation where the study was conducted and to request permission to do the research by collecting data from their employees who have experience in Cloud migration. Once the approval letter from the organisation had been received, the second step was to apply for ethical clearance from the university by attaching the approval letter from the organisation. Data collection and data analysis is the third step.

5.3 Research Participants

Table 5.1 consist of a list of research participants who were interviewed. The participants were selected based on their years of experience in making Cloud decisions. Each participant has over 15 years of industry experience and in their current roles, they are responsible for making decisions on migrating applications to the Cloud or adopting new Cloud solutions.

Table 5.1: Interview Participation List

Pseudo name	**Role**	**Cloud Decision Influence**
Participant A	IT Infrastructure Manager	Influences and decides on solution
Participant B	IT Architect	Design IT Solution, decides on solution
Participant C	Head: Digital Payments	Set direction and approval
Participant D	Head: Strategy	Set direction
Participant E	Chief Information Officer	Set direction and approval

The experience that the participants have gained over the years will ensure that the data collected is of quality and value for the research.

5.3.1 The Expertise of the Participants

Participant A is an IT Infrastructure Manager who is responsible for the entire IT infrastructure within the organisation. This manager is responsible for the server infrastructure, backup solutions, enterprise storage, networking, databases, and operating systems. Some of the components that are managed by Participant A are hosted in the Cloud. Participant B is responsible for designing solutions for the organisation when taking into consideration the integration requirements and hosting solutions. Participant C is responsible for Digital Payments that integrate with internal applications and external applications provided by third parties. Participant D is responsible for defining the organisational strategy, thus working in partnership with Participant E who oversees all IT operations within the organisation.

The participants have comprehensive knowledge of and experience with Cloud computing and decisions concerning the migration of applications to the Cloud. Due to their experience with Cloud decisions, their contribution will provide valuable input on how the HCMDF can be improved. The improvement of the HCMDF will provide an opportunity for future work.

5.4 Meeting Schedules

The participants were asked in advance if they would be interested in participating in the research. Six participants were requested to take part in data collection, however, out of six participants, only five were available to attend the meeting. Each meeting was scheduled for one hour, divided in 30 minutes for the presentation of the HCMDF and the remaining 30 minutes for interview questions. The participants were interviewed individually and there were no group sessions for data collection. The interviews are discussed in Chapter 3, Section 3.3.4.

5.5 Data Collection and Evaluation

The research participants have been asked the following questions. More detail on how the questions where derived is discussed in Section 3.3.5.1.5.

- *IQ1.1: Does the HCMDF consider a holistic approach to decisions about Cloud adoption?*
- *IQ1.2 Advice whether you will be able to use HCMDF is any Cloud decision?*

- *IQ2.1: Does the HCMDF consider factors other than cost in the decision-making process?*

- *IQ2.2: Which other factors should be included in the decision-making process?*

- *IQ3: Does the HCMDF lead to more understanding of the issues involved in decision-making?*
- *IQ4.1: Does the HCMDF provide clear and specific steps to follow?*
- *IQ4.2: Is the HCMDF process clear to follow?*
- *IQ4.3: Do you find it easy to apply the HCMDF without supervision?*

Questions to determine what improvements can be made to the HCMDF

- *IQ5.1: Is anything redundant in the HCMDF?*
- *IQ5.2: Which part of HCMDF is not required for decision-making around Cloud adoption?*
- *IQ6.1: What changes to the HCMDF would you suggest?*
- *IQ6.2 Are there other components that need to be added to the HCMDF to make it more holistic?*

Question 1

- *IQ1.1: Does the HCMDF consider a holistic approach to decisions about Cloud migration?*
- *IQ1.2 Advice whether you will be able to use HCMDF is any Cloud decision?*

Participant A:

> I would say it does, specifically because Cloud is a very new thing for us. Our Cloud consumption is indirect with partnership with Direct Transact and BankServ but we have not made that deliberately stating we want to go out there. It is more of an outsourced model. In terms of the model, I am very keen because it takes into account the issues of capability metrics. I like what you mention around the RAM, the reliability availability and maintainability. It is more specially about reliability. When you procure a system, it is about the effectiveness of that system. The system must do what you brought it to do and I think if you as a precursor for any Cloud assessment or adoption, if you look at that; to say that instead of getting excited of the noise, let's rather look at our application. Are we happy? That level of dependability assessment talks to that. Are we happy? It is a thing I think we need to chain differently. I was

really happy about that. Also around issues around BSC, I was also very pleased about that because it talks about performance management.

BSC is about performance management so I was quite happy that you can link that with the Cloud adoption because there are other solutions like HR systems that can make the organisation a bit more agile in terms of performance management. And even in terms of Cloud readiness assessment I think you also touched on that, I think the organisation to some degree is ready to adopt some Cloud solutions. The key dependency is our network to make sure we have adequate network capacity and also the cultural change is a big part of it. And the migration strategy you already touched on that. It is very important in terms of how are we going to get there. Part of what we are doing with the Office 365 assessment is actually looking at two points. How are we going to move this thing there? That is why we are doing assessment. Number two, also touches on dependability because we are saying we do not want to move something we do not know and it doesn't serve out purpose. How will the user experience be in the Cloud? How will it be different?

Participant B:

It does cover. It is quite broad. I feel there are other portions which might have been overlooked in terms of issue of integration part such as what other systems are we integrating this system with. If you migrate an application to the Cloud what will be the dependency on the applications still on premise? For example is it a core system or is just a line of business system only, those factors need to be factored in as well. Dependability assessment shouldn't only be about RAM, it should also add interoperability.

Participant C:

Yes definitely, if you start with the phases and go through them from A to D it will definitely assist. Dependability assessment will help you see if the system is a candidate for moving there in the first place. Value assessment will look at whether you are going to get value from the system if you move it to the Cloud. Cloud readiness; I think definitely. You have to look at that because there might be a lot of

factors which might contribute to the system not being Cloud ready. It is good enough to say they can host your legacy system there but it may be on such old technology that they are not able to support that technology anymore so at that stage you might look at replacing it with something that is already in the Cloud if you want to go that route. It would anyway put you in a bad situation if your system is so old and relying on technology that is not available anymore so it would be a good candidate for getting a Cloud solution to replace your existing solution than just to move your existing solution there. If you are struggling to maintain the hardware that the application is running on and you have to move it constantly then the Cloud hosting companies will have the same struggle in terms of hosting the solution. Then you will have to move to a move suitable solution.

I understand what you are saying there but it shouldn't take for granted the infrastructure as a service that they also need to keep up with the latest hardware and latest infrastructure. If your application is running on outdated infrastructure you will struggle to find a Cloud solution that will be able to host that old technology because they will not be able to guarantee your service if the infrastructure it will run on is not up to date. So it is something to think about when looking at your migration strategy selector. If you are at that stage where your legacy application is difficult to host then rather start looking for new application. You can still take portions of that application and put them in the Cloud. This is also a holistic view so you are not just looking at one item. If you are looking at the migration strategy selector be careful to not put your risk on the Cloud hosting. If its high risk for you to keep old technology they will also be reluctant unless they have lots of clients with old application but if you are the only client with old application that requires the old infrastructure then they will be reluctant to host you. It will become unreliable and they have to give you that guarantee which will cost you large amounts to do that.

Participant D:

Absolutely. So I am thinking now at the back of my mind. Where would I put the Total Cost of Ownership (TCO)? Yes it must come under the BSC under the financials but perhaps that is even the initial spend on the Cloud strategy. Does that

account for TCO of this thing which may be amortised over five years or whatever the case might be?

It is holistic. I think it might have to explicitly include: what is the total cost of all of this? Is it the value assessment? Does it come there? Is it value for the organisation to migrate to the Cloud? Because then you can bring in the value of the TCO and say actually the TCO is we will be spending less on the Cloud strategy than we do currently on-premise deployment. So TCO could come in there, again maybe it is in the BSC aspect but that value needs to be quite clear. It is a big thing, we are working for a bank, and people will say are we saving money. When is the value for us to migrate to the Cloud?

Learning and development. What is missing is the culture of the organisation. It is the lifecycle of an organisation and speaks a bit to the growth, sustain and harvest. Where are we as an organisation? This is from cultural perspective. There is some hard stuff that we can do in terms of assessment here but there is a softer issue which is the people part. Are we even ready? Can we buy into this whole concept? What kind of culture do we have here? Do we have a digital culture that we understand, that all of this, that we can buy into that. That can sink any digital transformation. When I look at this from on-premise to the Cloud, I look at this as a digital initiative. For example, the digital initiative is not just about technology and the hard stuff is also about the people. Can we adopt? Who is going to support this thing? Are we going to be seen positively supporting it or are we going to sabotage ourselves. That is the one part I am missing.

Participant E:

I think the framework does cover the big approach. I just have a slight different view if whether you should be starting with the assessment. If you are looking at it from pure business perspective, you probably should be starting with the value assessment because if you look at the frequently used paradigm between IT and business is that business drives IT. For instance, when developing strategy, you develop the business strategy and part of that business strategy becomes an IT strategy. If at some point on the other hand you define an IT strategy you still have to make sure that it fits into business strategy so you have that continuous alignment. My issue is that the

dependability is based on the RAM metrics, and RAM metrics spea almost exclusively to technology aspects. You can look at that. You might still feel that you want to start with dependability assessment, it's not necessarily wrong but I think you will have to justify.

Question 2

- *IQ2.1: Does the HCMDF consider factors other than cost in the decision-making process?*
- *IQ2.2: What other factors should be included in the decision-making process?*

Participant A:

I am not sure if I can say added, but more of evangelization. Because sometimes some of this decisions; the business makes them without taking into account many factors. So I will say it is one of the things that needs to be taken into account. I am not sure if I can slot it into the process but what I can say is the right people must be assigned to drive the Cloud adoption and assessment strategy. There must be a forum where this needs to be taken to. Even if it's not IT, if it is business that is thinking of putting something in the Cloud, there must be appropriate forums for that. I think the Technology Architecture Forum (TAF) is part of it. There are other forums. Sometimes there is no structure. Cloud is a buzzword so there is not what I would call a Cloud committee. No one is saying if I am thinking of Cloud, where do I go? This committees are there to serve many purposes. Maybe it could be part of it, that when you are thinking of taking things out there then you have to take it to the right place.

Participant B:

I think there is cost in terms of data cost, the additional cost in addition to license costs.

Participant C:

Factors you need to keep in mind is your *regulatory and compliance*. As a bank you cannot host your core banking on the Cloud that is hosted outside of the country. It

has to be a Cloud that caters for your regulatory requirements. As a bank you cannot host your customer data outside the borders of the country.

Participant D:

It is a *competitive factor* that is unique for every organisation. So if you have 10 competitors and all of them are adopting Cloud, there are certain operating models that enable you to leverage Cloud strategy a lot more efficiently. So you are the only one out of the ten who is adopting Cloud which is a totally different business model which might disadvantage you? If you look at the whole self-account opening process that Tyme Bank, Discovery Bank and all the other guys want to bring on. Let me just call it a business model because the world changes and as the world changes, different players adopt different types of business models. We are getting to a point where this is a business model that makes sense to everybody because this is the way the world is and if you don't adopt that business model you might as well be left out. So for competitive advantage, there are certain trends. For example the guys that have Cloud deployments find it *easy to provide open APIs* to third-parties for their applications and services. You who has an on-premise deployment you will find it hard to provide open APIs for third-party developers to plug into you and develop and provide services for you. From a competitive perspective, if we are going the route of open API, everyone has kind of seen where the world is going it is easier to open APIs.

Participant E:

I don't think of a separate category that you might want to add but you can possibly add to some of these categories particularly from *governance perspective*. You want at some point to or the other to ensure that you talk to those things related to *risk management*. I think those needs to come out strongly. I am also thinking at the back of my mind that maybe you need to refer for instance to value IT (maybe you have done it in your body of work) when you start talking about some of this aspects for instance value assessment there is something like VALIT as an example to say what does VALIT espouse those things you use to measure value. So when you talk about

value assessment, beyond the generic items you might want to look at it from that perspective.

In terms of the governance as well, you might want "in your mind" to have a reference point specific to governance. COBIT as an example, I am not talking about all of it, but you might want to focus on one or two aspects that you want to relate to. Just like even from a financial perspective, I would suggest you engage a financial professional. Just so that you can probably refer to a simple model like (Net Present Value) NPV or something simpler, but you want something that has been tested by someone who is looking at it purely from financial perspective, because your audience will include a whole lot of people and some of them will have very strong financial competencies will come in. It is not about satisfying what they want but it must be something from which from a financial perspective is sound to them.

Question3

IQ3: Does the HCMDF lead to more understanding of the issues involved in decision-making?

Participant A:

Yes, definitely because as I have indicated earlier, it takes into account for the system you currently have today (that's where you talked about the application catalogue). The application we have today is it meeting business requirements? By starting with that you are not looking at cost. The system we have today we bought it for specific purpose, is it meeting our requirements? The system is an investment. Are we getting more than what we invested? That is the basic tenant of meeting this requirement. For example, if I have bought something for ten thousand rand, is it functioning the way it is supposed to function? As a consequence of what it is supposed to do, am I then able to make money out of it? Am I able to generate revenue to justify the investment? When you are saying you are going to the Cloud then you are not talking about effectiveness, you are not talking about meeting requirements you are talking about maximising the value of something. The conversation shifts to efficiency. Effectiveness means this thing (like you have given an example) is doing what it is supposed to. I am able to derive value from it, whereas efficiency means yes we are happy it is doing what is supposed to do but there are other means were can invest in

to maximising value from it. Someone can sell you a dream and tell you I can do things differently and maybe faster but it breaks more often.

Participant B:

It does. It's broad.

Participant C:

Yes, certainly. Normally people just look at the costs but they don't look at all factors but if you look at this list, although there is a few things that should be added, it gives you a very good indication of which systems can be considered for Cloud readiness. So all this factors, the business and technology factors, the training of staff. If you as a company is not prepared to invest in your staff such as IT personnel you are going to get reluctance from them when you are looking for a Cloud solution because they will see it as a means to get rid of them. If you look at technical resources looking after your infrastructure, if they are not skilled up in the Cloud and see value of it by gaining more experience in that area they will see it as a way of being retrenched or eliminated. If you look at this it will give you more insight into which systems are ready for Cloud migration.

Participant D:

It does.

Participant E:

I think it does help. It's important to understand the financial impact but there is always more to this than financial impact being strong as a contributor. You can have instance where for instance the operational risk associated with using the platform actually becoming compelling to take a decision like this. Obviously the financial might probably affect your decision in terms of the platform that you choose. You may decide to go for the cost effective platform, but the decision to say now you have

to move to Cloud for instance the operational factors may be stronger that any financial considerations you have to make. Operational risk in general, you can even have specific issues like security for instance. For instance if there is a vulnerability which is extremely difficult to mitigate for which there is no convincing solution as an example, you might have to think of instances where there is obsolete technology or even a platform that simply does not meet business requirements.

Question 4

- *IQ4.1: Does the HCMDF provide clear and specific steps to follow?*
- *IQ4.2: Is the HCMDF process clear to follow?*
- *IQ4.3: Do you find it easy to apply the HCMDF without supervision?*

Participant A:

I would say the process is easy to follow, it is linking technology investment to business outcomes which is that dependability assessment. The second thing you saying once I have done the assessment then how do I get there in terms of implementation. I would say it is very sequential? You can do without supervision. It is very straight forward, very easy to follow.

Participant B:

It covers more of the business approach. From the business perspectives yes maybe it is broad enough. From IT perspective in terms of the drivers there are things like interoperability that are missing. You also have to have your architecture principles that should be incorporated. As a company do you want to adopt leading edge technology or you want things that are stable and traditional. The edge that business have is covered by your principles as what kind of organisation you are. You find the architecture team are the ones that sphere head the decision to move. Yes you do have your aspects of your monitoring in terms of a dependability assessment. The aspect of the value assessment is more of a business assessment. Architecture principles can be put on Phase C which is organisational readiness. With regards to this "You can do without supervision" – I would say yes.

Participant C:

> It looks straightforward. I don't see anything that will make it complicated to follow. Obviously not all systems are going to have the same key factors. Not all systems can be measured in response times. For a system which you have bought, you might not be aware of the throughput of that application. Maybe not supervision, but you might need the assistance of the vendor to understand the *(sic)* key factors and to measure them. If it's an in-house developed system then you will have more insight into this areas. A lot of this systems this days are off-the-shelf packages that you buy which mean you will have significant input from the vendors to be able to answer a lot of this questions as you go through the phases of process.

Participant D:

> I think it is. I don't know if it needs to run sequentially though, whether certain aspects of this cannot run in parallel. So I understand the decision is either option A or option B but I am thinking it can run in parallel so we can get the options we want to get. Again it depends from resourcing perspective, how many people do you have looking at this and how do you want to position this framework for people to look at. For example you will have some operational guy looking at the BSC, should they wait or should they run it in parallel.

Participant E:

> I think it can be applied without supervision but you probably need to put more in terms of explaining before one gets to the process. The second point for me is that if we are looking at it as a process then you must have a start point and an end point and each of the phases will need to have decision points and it must be clear what the impact of the yes or no decision. You close the loop so you don't have anything that remain open ended. You might want to have a process chart or a flow chart that allows you to walk through this but you have to make provision for that logical type approach decision aspects, like what would happen if one does dependability

assessment and the outcome is this or the other. Sometimes the outcome is not black or white, it is grey so you have to make a way to make provision for that.

Question 5

- *IQ5.1: Is anything redundant in the HCMDF?*
- *IQ5.2: Which part of the HCMDF is not required for decision-making around Cloud adoption?*

Participant A:

Value assessment and dependability assessment can be converged into one item. When talking about availability and reliability, you are not speaking in general terms, you are looking at it system per system. You might not need all the components of the BSC to check the effectiveness of an HR system. When people apply for leave or check their payslips and so on, how easy is it for management to conduct performance management on their direct reports. How easy is it for direct reports to provide feedback in terms of performance challenges? That might not get to financials. If I say "is the system reliable?" all this talks to business requirements, is it delivering the value that I paid for? If you talking about available, is it available for me to use it for business purposes. If you talk about maintainability, how easy is it to fix it when it is broken. You can keep it the same but for some applications the value assessment might not be applicable. For core systems it will touch on other elements of the BSC.

Participant B:

I am not sure where the learning and growth perspective, where it fits in. This can be put under Cloud readiness.

Participant C:

I think this gives a good baseline of what to work with. There may be some of the systems that do not have some of the required items. Phase A I can see most of them being relevant for most systems. Phase B maybe some of the items will not be relevant for all systems. Definitely as a basis to start with is a very good framework.

You will have to look at it for each type of system, which of this will not be relevant. There may be internal systems that you use that will not need brand, because they are not customer facing systems. They may only require items for internal stuff and they may not relate to products and customers. It is definitely quite comprehensive in terms of the phases it goes through.

Participant E:

I wouldn't recommend approaching it from that perspective. For now I think leave that scope open.

Question 6

- *IQ6.1: What changes to the HCMDF would you suggest?*
- *IQ6.2 Are there other components that need to be added to HCMDF to make it more holistic?*

Participant B:

Industry trends. Are we leaders or followers? You might not want to be the first one to launch a Cloud solution while others are not doing it or we might be the ones to do it because we want to be the leaders and because we can afford to be like that as well. *(sic)*

Participant C:

Components that should be added are regulatory and compliance, here you will need to see what type of regulation is required for the type of system that you want to look at. You can look at that in terms of Cloud migration selector to say, you may look at IaaS if you have a system that is already catered for in terms of regulatory requirement and it is customised to look at everything that your company needs for regulatory requirements and it will be difficult to find another system. So you may have to add those type of requirements. Firstly in deciding whether it is a system that is a candidate for migration and secondly if it is then which strategy needs to be followed for that system. *(sic)*

Participant E:

> With the migration strategy, you could approach it in phases or big bang, those are some of the things to be incorporated as well. Change management from business and business impact assessment is important. Communication and awareness and even training, those are the other key elements of change management.*(sic)*

5.6 Data Analysis

- *IQ1.1: Does the HCMDF consider a holistic approach to decisions about Cloud adoption?*
- *IQ1.2 Advice whether you will be able to use HCMDF is any Cloud decision?*

Participants A, B, C, D and E all agreed that the artefact considers a holistic approach to Cloud migration and that they will be able to use the framework in Cloud migration decision. Participant A provided the following reasons why they would consider the framework "I am very keen because it takes into account the issues of capability metrics" and that "the system must do what you bought it to do". The participant was also pleased with the integration of the BSC as it relates to performance management within the organisation. The principle of using capability metrics in the design of HCMDF was to ensure that client organisations make Cloud migration decisions based on supporting and factual data rather than on assumptions and the hype of Cloud migration.

Although participant B also agrees, their view is that integration and interoperability is missing from the HCMDF; when an application is migrated to the Cloud there will be dependencies on integration between the Cloud application and the applications hosted on-premise. The participant suggested that the RAM model should also add interoperability. Participant C stated that starting with dependability helps to identify which of the applications are candidates for migrating to the Cloud in the first place, however, they cautioned about transferring an IT risk to the CSP stating that "if it's high risk for you to keep old technology they will also be reluctant" and recommended that if the client organisation has a legacy system that is too old then a replacement system should be considered.

Participant D was concerned about the TCO for the client organisation and said that the framework would need to state explicitly what the total cost will be. The other factor that Participant D stated as missing, is the culture and lifecycle of the organisation. The culture refers to the "people" part and that the client organisation must ascertain whether they have a well understood digital culture because the absence of that can "sink any digital initiative".

For participant E, the approach was a concern, stating that they "have a different view if *(sic)* whether you should start with the assessment". Participant E made the argument that "business drives IT" and that even if IT develops a strategy, that strategy will need to have continuous alignment with the business strategy.

- *IQ2.1: Does the HCMDF consider factors other than cost in the decision-making process?*
- *IQ2.2: Which other factors should be included in the decision-making process?*

Participant B asserted that there should be additional factors such as the cost of data – in addition to the license costs. Participant A stated that something to take into account, is that the "right people must be assigned to drive the Cloud adoption and assessment strategy" and that "there must be a forum" where these discussions can take place. Within the organisation there are multiple forums, serving various purposes, but that there should be a Cloud committee for people who consider Cloud initiatives as an answer to the question "If am thinking of Cloud, where do I go?", thereby taking the discussion to the correct forum. Participant C stated that the framework should include regulations and compliance. This is important for the bank since the bank cannot select a Cloud solution that is hosted outside the borders of the country. For Participant D, the competitive factor should be considered for the framework since this is unique to every organisation.

The example that Participant D used, is that client organisations that have Cloud deployments, have open APIs that allow third-party developers to develop and provide services to the client organisation. Participant E submitted that governance should be included and that items related to risk management must be included in the framework. Participant E also added that one can consider adding Val IT, which will assist in value assessment beyond the generic aspect. From a governance perspective, participant E suggested that a reference point to known and accepted frameworks, such as COBIT, should be considered even though it is just for one or two aspects of it. Another factor for Participant E involves finance and they suggested that "you can engage with a financial professional...so that you can probably refer to a simpler model like NPV .....Something that has been tested by someone looking at it purely from *(sic)* financial perspective" since this will be something that is sound to the finance professional.

- *IQ3: Does the HCMDF lead to a better understanding of the issues involved in decision making?*

Participant A said: "Yes, definitely because as I have indicated earlier, it takes into account for the system you currently have". Furthermore the participant stated that the system should perform what is expected of it saying that "the system is an investment" and that when a system is purchased, they should be able to generate revenue from that system and that the system should be efficient. Participant D did not provide any comments but stated that the system does lead to a better understanding and that it is broad. Participant C agreed that the HCMDF leads to more understanding of the issues involved in decision-making, saying that when you look at the HCMDF, "it gives a very good indication of which systems can be considered for Cloud readiness". The participant referred to investment in IT personnel as being important, because if staff are not trained, they will see the migration "as a means to get rid of them" and "you are going to get reluctance from them".

Participant D simply agreed that the HCMDF leads to more understanding of the issues involved in decision making by saying "it does". Participant E agreed that the HCMDF helps, but also highlighted that the financial part might not always be an important factor since operational risk can be more important as a "compelling reason to take a decision" to migrate to the Cloud. The participant's second example is that "there is a vulnerability which is extremely difficult to mitigate for which there is no convincing solution*(sic)*. This vulnerability can cause the client organisation to look for a Cloud solution. Other possible factors are, when the on-premise solution is of "obsolete technology or even a platform that does not meet business requirement".

- *IQ4.1: Does the HCMDF provide clear and specific steps to follow?*
- *IQ4.2: Is the HCMDF process clear to follow?*
- *IQ4.3: Do you find it easy to apply the HCMDF without supervision?*

All participants agreed that the HCDMF is easy to follow as a process, however, Participant D suggested that the process does not need to be sequential and that it can run in parallel so "we can get to the options that we want to get". The participant also pointed to the staffing issue: that it will determine how many people will be working on the HCMDF and that when an operational person is working on the BSC, whether other staff members will have to wait for one phase to complete before proceeding with the next phase. As regards Participant D's comment: the HCMDF was designed as a framework that can be applied in sequence, however, it is possible to execute parts of the phases in parallel. That said, although some

parts can be executed in parallel, it will not be possible to start Phase B unless Phase A is completed since Phase A's output is an input to Phase B.

Within the BSC, multiple parts of the BSC can be executed in parallel since they exist in one Phase. The phases depend on the previous phases. HCMDF is designed in a way that there is no wasted effort, for example, the application that is being considered for migration has to pass each phase sequentially because there is no way to decide on the migration of the application and it is still to be ascertained whether the application meets the criteria to be migrated. Participant E suggested that and the HCMDF might need "to have a process chart or a flow chart that allows you to walk through". This suggestion will help to ensure that the process is applied correctly. The presentation of the HCMDF was conducted by following a walk through document (See APPENDIX F) which facilitated the process to follow.

Participants A's response was that the dependability assessment process links technology investment to business outcome and that the process is "straightforward, very easy to follow". According to Participant B, the process addresses the business aspect more and stated that the value assessment is more of a business than an IT assessment. Participant B said that the interoperability and the architecture principles are missing, considering that the architecture principles provide a business with the “edge” since they define whether the company is a leading-edge company (using the latest technology) or if it is more of a follower. According to Participant B, the architecture principles are the ones that "sphere *(sic)* head the decision to move" to the Cloud. This is somewhat in contrast to Participant E's approach since the participant said that the process should be driven from the business viewpoint and not from that of IT; and that the value and not dependability assessment should be prioritised. Both views by Participant B and E on the approach are valid, however, the HCMDF was designed to start evaluating applications to be considered for migration and to determine if the applications are performing as expected when hosted on-premise. From a business perspective, migrating the application to the Cloud might be considered; but by applying the HCMDF, the reason for migration should be valid and not because the Cloud is a buzzword as highlighted by Participant A in Question 2.

Participant C stated that the process is easy to follow although not all factors will be valid for every type of application. The participant also suggested that for Cloud solutions, the CSP will be required to provide input since they will know the metrics that are calculated and that a client organisation will only be aware of the metrics for on-premise solutions. The

dependability assessment of the HCMDF focuses on internal applications that need to be migrated to the Cloud and it is limited to that. The CSP involvement will be considered for a solution that is hosted in the Cloud when that solution is being evaluated, however, for the purpose of migrating on-premise applications to the Cloud, the CSP will not be involved in evaluating the dependability of the on-premise solution. The client organisation will conduct the evaluation and will retain the historical data for the duration of the assessment.

- *IQ5.1: Is anything redundant in the HCMDF?*
- *IQ5.2: Which part of the HCMDF is not required for decision-making around Cloud adoption?*

Participant A said that the value assessment and dependability assessment can be combined and suggested that "you might not need all the components of the BSC to check the effectiveness of a Human Resource (HR) system". The participant also stated that they consider reliability from a business perspective, saying that reliability "talks to business requirements". Participant A agreed that the dependability and value assessments can be kept as is.

The design of the HCMDF takes into consideration that there are business as well as IT aspects to be considered. Although the two are aligned, for example, when a system is not reliable or available or in maintenance, the business will still be affected. Although maintainability could be planned and communicated to business in advance, when an application is not reliable or not available, the business will be negatively affected and will need corrective action. These are technical issues that will be addressed by IT, hence the dependability assessment is performed from an IT perspective since IT will have the data to analyse this information in detail. However, it is possible to put the RAM model and Value assessment together since they serve the same purpose, namely to evaluate if the on-premise application is performing as expected from both IT and business perspectives.

Participant B was unsure of where the learning and growth perspectives of the BSC fits in and suggested they be placed under Cloud readiness. This suggestion will also be considered for future development. The learning and growth perspective will fit in the Cloud readiness section as it is also about ensuring that the client organisation's staff is ready to work on and support the application when hosted in the Cloud. Participant C agrees with this approach (as answered in Question 3) by saying that if the client organisation is not prepared to invest in their IT personnel, the personnel might be reluctant to access the Cloud solution because

"they will see it as a means to get rid of them". This notion speaks to staff being ready to accept and make use of the application when hosted in the Cloud.

Answering Question 3, Participant C said that "I think this gives a good baseline of what to work with", however, the participant also held a similar view to Participant A, that all factors will not be relevant to some applications. The participant stated that one would have to consider the evaluation per application, since "there might be internal systems that will not need brand, because they are not customer facing systems". Participant E does not agree that the current approach should be followed but stated that the scope must be left open for consideration at present. The participant expressed the same view of Question 1, stating that the process should be initiated from a business angle and not from IT. In closing, regarding redundant factors or changes, Participant A suggested that the Value and Dependability assessment can be combined, Participant B suggested for the Learning and Growth Perspective to be conducted in Phase C for Cloud readiness, and Participant E suggested the approach should be from a business perspective.

- *IQ6.1: What changes would you suggest to the HCMDF?*
- *IQ6.2: Are there other components that need to be added to the HCMDF to make it more holistic?*

Participant B stated that industry trend should be added, providing the client organisation with knowledge of developments taking place in the market. Depending on whether the client organisation is a leader or follower in the market, they will be able to keep up with the latest technology. Participant C made recommendations on regulations and compliance. As regards the migration selector, the client organisation can select a system that is already compliant with regulatory requirements.

5.6.1 Results

All participants agreed that the HCMDF is holistic given that they would be able to apply the HCMDF in Cloud migration decisions. Participant E, however, was not convinced and declared that the process must be driven from a business perspective because IT strategy ought to support business strategy.

All participants agreed that the framework considers many factors for migration and have also suggested other factors that are important and should be included to make the HCMDF more holistic. These factors are: the total cost of operating the solution (such as data costs) in addition to the cost of the solution, along with competitive factors, governance, compliance, and industry frameworks

All participants agreed that the HCMDF provides more understanding of the issues involved in Cloud migration decision making.

All participants agreed that the process is easy to follow and can be done without supervision. Nevertheless, they suggested that the phases of the HCMDF be executed in parallel, and that there should be a document or process chart to guide users.

5.6.2 Future Improvements

Questions 5 and 6 were designed to gather input from participants to determine which part of the HCMDF can be improved. These suggestions include the convergence of the Value and Dependability assessments since they serve the same purpose. It was also suggested that the Learning and Growth perspectives of the BSC move to Organisational Readiness Phase C seeing that it speaks to ensuring staff readiness for the Cloud solution. Another suggestion is to start the process from a business and not from an IT perspective because business defines strategy and IT must be aligned with that. Business change management and business impact assessment are also recommended additions that will include the organisational business change involving communication and awareness.

5.7 Chapter Summary

The purpose of this chapter was to evaluate the HCMDF in a real-world environment by interviewing decision-makers responsible for making Cloud migration decisions within their organisations. In total, five participants were interviewed, each with disparate backgrounds and different roles concerning Cloud migration.

CHAPTER 6 – CONCLUSION

6.1 Introduction

This research aimed to contribute towards the simplification of Cloud migration decisions at an organisational level. To this end, the dissertation adopted a Design Science Research strategy and an adaptive case study. It is argued that the existing methods for Cloud migration decision do not provide organisations with a universal approach to migration and a universal solution is required to simplify the migration decisions.

This chapter concludes the dissertation by providing feedback on the research effort and the findings. This chapter is structured as follows: Section 6.2 provides the overview of the dissertation, Section 6.3 findings of the research, Section 6.4 discusses the dissertation contributions

6.2 Dissertation Overview

Chapter 1 provided an introduction to the problem statement. Client organisations aiming to migrate their on-premise applications to the Cloud have to select various migration strategies from CSPs and researchers. The various approaches are not universal and each migration intent is achieved with different migration strategies depending on the application to be migrated and the CSP that will host the application. The literature review revealed that there is no universal approach for migrating on-premise applications to the Cloud from either academia or practitioner communities. Practitioners provide migration approaches that are specific to migrating applications to their discrete Cloud platforms, and the research community has contributed various frameworks that differ in terms of applicability. The chapter concluded with a problem description and four criteria that are required for a universal migration process.

Chapter 2 presented a background on CC by first stating the CC definition followed by the characteristics of CC. CC background aims to provide context and understanding on the CC technology and how organisations can benefit from it. A literature review on CC revealed that CC is made up of deployment models, service models and service attributes. These deployment models provide the characteristics of different types of Clouds; namely, public Cloud, private Cloud, hybrid Cloud and community Cloud. The CC service models provide details on the type of Cloud services available. The basic CC services are IaaS, PaaS and

SaaS. The service attributes provides details of how CC services are accessed (broad network access), how CC is billed (measured service), the level of autonomy of resource (on-demand / self-service) and the scale of CC resources (rapid elasticity). Together, the characteristics of CC provide organisations with compelling benefits to migrate to the Cloud.

A literature review revealed that client organisations would like to migrate to the Cloud due to benefits like high availability, business agility, reduced IT costs, mobility, resource scalability, and maintenance and support associated with the Cloud. Along with the benefits of CC, the literature review also uncovered challenges to Cloud migration. These challenges lead to organisations being hesitant to move their applications to the Cloud. High on the list is lack of CC standards, business continuity and availability, interoperability, vendor lock-in, and the dependability of the CSP.

Through the literature review, it was determined that there is little research on the difficulty of migrating applications to the Cloud due to the various migration approaches provided by CSPs and practitioners. The lack of a universal approach to migrating applications to the Cloud led to the problem statement. The remainder of the chapter (Section 2.11) focused on refining the problem statement and the solution criteria discussed in Chapter 1, Section 1.3.

Chapter 3 discussed the research strategy that was followed in the dissertation. The research strategy that was applied in this dissertation is Design Science Research. The purpose of a DSR research strategy is to produce a research artefact towards solving or improving a business problem. The research artefact is the HCMDF. The research strategy was approached by first conducting a literature review on CC adoption to understand the challenges to CC adoption. Throughout the literature review, it became apparent that organisations that want to migrate to the Cloud are faced with various approaches to Cloud migration that they have to understand and follow. Practitioner documentation on Cloud adoption is focused on how client organisations can migrate applications to the CSPs specific Cloud. These varying approaches to CSP spiked an interest in developing a simplified decision framework for migrating on-premise applications to the Cloud for any CSP. This approach assisted in putting the focus on Cloud migration, therefor the literature review was more specific to Cloud migration.

Chapter 4 outlined how the design of the artefact would be achieved. Based on various factors such as applications, organisational benefits, migration strategies, and the lack of a universal approach, the design envisioned was a framework that would incorporate various

decision points into the framework. The various decision points led to the idea of building-blocks, where each building block is a complete unit that is independent of other decision points. A further literature review was conducted around the decision points to construct the building-blocks – called phases. The result of Chapter 4 is an artefact in the form of a framework called a Holistic Cloud Migration Decision Framework (HCMDF).

Chapter 5 discusses the findings of the dissertation. The results were interpreted by looking for positive responses to the interview questions. Each interview question was asked to provide either an agreement or disagreement together with elaboration on why the specific answer was chosen. The findings are discussed in Section 6.3.

6.3 Findings from the Dissertation

The dissertation aimed to develop a Cloud migration decision framework to solve the problem description:

There is no universal approach for migrating on-premise applications to the Cloud.

Four solution criteria were identified to solve the problem description and they are:

Firstly, the solution should be able to provide client organisations with a clear method for selecting applications for migration,

Secondly, the solution should provide client organisations with a clear approach for identifying the drivers for the migration intent,

Thirdly, the solution should provide a clear process to select the best migrating strategy and the fourth criterion is for the solution to apply to any client organisation.

The solution that has been proposed is called a

Holistic Cloud Migration Decision Framework (HCMDF).

This section discusses the findings of the dissertation. The findings will state how the problem description was solved by the HCMDF. To determine if the HCMDF solves the problem description, it had to be evaluated for its efficacy in a real-world environment by interviewing Cloud decision-makers. A select group of five Cloud decision-makers were interviewed and their responses are the data that was collected and analysed. There were no group sessions and each participant was independent in the discussion and on the understanding of the HCMDF. The next section discusses how the HCMDF solves the problem by meeting the solution criteria.

The first criterion to be discussed is

The HCMDF should provide clear application criteria for migration

These criteria aim to evaluate whether the on-premise application is dependable by assessing the application. To achieve this, a dependability assessment is conducted. The dependability assessment uses an existing tool in academia that measures an application's availability, reliability and maintainability. This dependability tool is commonly used in engineering studies and often referred to as the RAM model. Making use of an existing tool ensures that the tool used in the framework has been researched and can be relied on. The RAM model provides metrics that can be measured to determine if the application is dependable. The process to assess application dependability requires that the first step be sourcing the RAM metrics from the client organisation's help desk system, the second step is to measure these metrics against the client organisation's SLAs and the third step is determining if the evaluated application is complying with the metrics set by the client organisation. An application that fails to meet the client organisation's targeted SLA will then be considered for migration to the Cloud. The reason for migrating an application that cannot satisfy the SLA within the organisation is, because Cloud computing promises better availability and reliability compared to on-premise solutions. An application that is performing as expected does need to be migrated. This process can be repeated for any application since the metrics being evaluated against are predefined by the organisation and are not changing.

Research participants have agreed that the dependability assessment accomplishes the objective of having a methodology for selecting the right applications for migration. Some participants suggested that more metrics, such as interoperability can be added in addition to RAM. Other research participants suggested that the dependability assessment can be combined with other parts of the framework, however, no participant disagreed that the dependability assessment solves the application selection problem. It can therefore be concluded that the dependability assessment solves the application selection problem criteria.

The second solution criterion is:

There should be clear drivers for migration intent

To solve this criterion, the HCMDF is designed to evaluate the value of the migration for the client organisation. Value is determined by evaluating if there will be an organisational benefit by considering the client organisation's business strategy. Business strategy is

evaluated by using a tool called The Balanced Scorecard. The balanced scorecard is well documented and researched by other scholars, therefore the evaluation of a business value through the balanced scorecard implies that the value assessment is conducted by utilising a tool that has been tried and tested.

The balanced scorecard is used to evaluate the business value from four perspectives; namely, financial, customer, learning and growth, and business process. By evaluating business value from these four perspectives, the application being evaluated can be measured for its contribution to business value if it is migrated to the Cloud. The rationale for evaluating business value is that an application being considered for migration should benefit the client organisation.

Research participants agreed that assessing the value of the organisation is a relevant step in the processes. A person with experience on the application of the BSC will be required as there are multiple domains within the client organisation to be considered. Some research participants felt that the four perspectives are not sufficient and that more perspectives should be included. By measuring the business value, the application that is being considered for migration will always be measured against the perspective of the BSC. A migration that will not add value to the client organisation will not be considered for migration. The aim of evaluating business value is to align the business objectives with the application migration intent. The process of evaluating the business value can be repeated and will produce the same results for the same application.

The third criterion is:

The solution should provide a clear process to select the migration strategy

Each application requires a different migration strategy based on the complexity or ease of modification required for the application. An application that is difficult to modify will use a different strategy than the one used for an application that is simpler to modify. Off-the-shelf applications do not require modifications and are candidates for replacing on-premise applications that can be purchased off the shelf. By providing a clear migration strategy selector, client organisations can select the right migration strategy based on the application type. The migration strategy selector is used to evaluate the application to determine the correct migration strategy for that application. The process is repeatable and can be performed whenever there is the need to migrate an application to the Cloud.

Research participants agreed that the migration strategy selector is a viable approach and solves the migration strategy problem. During data collection, research participants demonstrated an understanding of and the need for multiple research strategies and also provided input relating to the migration of legacy systems to the Cloud.

The fourth criterion is that

The solution should apply to any organisation

The data gathered and evaluated demonstrates that the process that the HCMDF uses is repeatable and can be applied to any application that is being considered for migration. A universal approach was accomplished by designing the HCMDF in a way that is not specific to a CSPs Cloud and not specific to any application: the HCMDF can be applied when migrating any type of application to any CSP.

The solution criteria presented in this dissertation were accomplished through the design of the HCMDF. Research participants provided input on each of the criteria that was specified and their input needs to be explored for future development of the HCMDF. One person out of five expressed dissatisfaction with the starting point of the process and suggested that the HMCDF should start from the business perspective and not from the IT perspective since IT does not drive business decisions. From the data analysis (Chapter 5), the problem description has been resolved by defining the problem, defining the solution criteria to be achieved, defining the design criteria, designing the artefact to meet the design criteria, and designing the evaluation criteria based on the solution criteria. By following this process, it was possible to stay focused on the problem to be resolved.

6.4 Research Contribution

The contribution of this dissertation towards the practitioner community and the research community. The first contribution is to the practitioner community. A potential client organisation that is considering migrating their applications to the Cloud will have to consider which CSP will host their application. CSPs provides guidelines for migrating applications to their Cloud and their guidelines are specific to their Cloud platform. Client organisations reviewing multiple vendors will experience difficulties as they have to evaluate multiple migration strategies and create the complexity in migrating to the Cloud. Practitioners can use the HCMDF to guide organisations on how to migrate to their Clouds. Client organisations can use the HCMDF because it will simplify their migration to the

Cloud. The HCMDF is designed to make it easier for client organisations to understand why a particular application is better suited to the Cloud than another, making it simpler for client organisations to quantify the value of migrating to the Cloud.

The second contribution of this dissertation is to the research community. There are two main contributions. The first contribution is the input provided by the research participants. Input to the framework provides addition points for new areas of research. The second contribution is how the various tools were integrated to develop a universal decision framework for migrating to the Cloud. Cloud computing is not only about technology decisions since applications within the organisation have an impact on business strategic decisions.

6.5 Limitations of the Research and Suggestions for Further Research

The dissertation has two main limitations. The first limitation is that the study is only limited to the migration of applications to the Public Cloud and not to any other Cloud deployment model. Applications that are hosted on-premise are the considered. The second limitation is that the acquisition of a new Cloud solution is not within the scope of this research. These limitations do not imply that the HCMDF cannot be applied to other types of migration, however, a separate research would need to be conducted to determine the feasibility of the HCMDF in other Cloud migration scenarios.

Various suggestions on how to enhance the framework were provided by the research participants. The framework has four phases that each had suggestions. Phase A suggestions are: expand the RAM model to include other factors for evaluation and combine Phase A and Phase B to create a consolidated building-block for evaluation. The suggestion for Phase B is to add more perspectives in addition to the default perspectives of the BSC. The additional perspectives relate to risk management and compliance requirements. The last suggestion is to create a manual and process chart to guide the person who will be applying the artefact. These suggestions by research participants have expanded on how to improve the HCMDF for it to be more holistic and universal.

6.6 Final Remarks and Key Take-away Message

CC is a buzzword and some organisations might be migrating because of this; but many organisations are migrating to the Cloud for its benefits. The aim of this research is to assist decision-makers in making the right decisions when migrating their applications to the Cloud. This dissertation does not guide the reader on *why* they choose to migrate to the Cloud, but rather on *how* to migrate to the Cloud. Although the client organisation might have already

decided to migrate, the HCMDF will still help to guide the process and to ensure that the right applications are migrated to the Cloud.

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