USING AN ARCHITECTURAL APPROACH TO ENABLE APPLICATION MODERNISATION IN THE CONTEXT OF DIGITAL TRANSFORMATION

BY

MATLHODI ONICCAH NCWANA

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Dedication

To my mother, Joyce Ntsae Matsho, who is the pillar of my strength, as she has always been there for me, your unconditional love, wisdom, and constant guidance kept me going. Finally, I dedicate this Master's degree to the memory of my late brother, John Ratsweke Matsho (06/05/1971 – 23/10/2010). He believed in me wholeheartedly and was my greatest cheerleader. His faith in my potential continues to inspire me, and I will forever hold our memories close to my heart. This achievement stands as a testament to perseverance, faith, and the power of love and support. To all of you, thank you for being part of this journey and for making this accomplishment possible.

Abstract

Cloud migration has become a key business strategy, as it offers incredible benefits such as scalability, elasticity and cost effectiveness. Organisations remain cautious about applications migration to the cloud due to execution challenges and different security concerns. An architecturally driven organisation needs an appropriate architectural approach to ensure the effective facilitation of the information technology (IT) systems migration to cloud systems. The body of knowledge has grown significantly since the inception of this research, however, there remains the need for comprehensive and flexible strategies that can tackle the complexities of legacy systems migration from on-premises to cloud platforms. The study investigates the use of enterprise architecture (EA) in facilitating application modernisation and presents a comprehensive EA-driven framework. This research followed a design science research approach.

The study conducted a review of the existing literature to identify research gaps and inform the definition of design criteria that guided the development of the proposed framework for migrating information systems from on-premises infrastructure to cloud-based platforms. The proposed framework named arch cloud migration framework (ACMF) was evaluated by a team of experts, and their recommendations were be implemented to propose a second version of the framework to guide the aforesaid migration. The ACMF will enable organisations to modernise legacy applications while aligning with organisational strategy and transformation initiatives.

Key words: *Application modernisation, cloud migration, IT systems, Enterprise architecture, Internet of Things, framework.*

Table of Contents

Table of Figures.

Terms and definitions

Terms	Definition
CM	Cloud Migration
EA	Enterprise Architecture
AM	Application Modernisation
ACMF	Arch Cloud Migration Framework
DSR	Design Science Research
IOT	Internet of Things
KPIs	Key Performance Indicator
GDPR	General Data Protection Regulation
PoPI	Protection of Personal Information
PCI DSS	Payment Card Industry Data Security Standard
IRB	Institutional Review Board
AI	Artificial Intelligence
ECTA	Electronic Communications and Transactions Act

1 Research Introduction

Because of technologies such as Internet of Things (IoT), the ways of doing things are undergoing radical technological transformation (Li *et al.*, 2018). Consequently, almost everything is now done digitally. This poses a challenge to organisations that wish to remain competitive in the digital world (Zhou, 2014). The competitive marketplace and the commercial changes have driven organisations to implement different state-of-the-art information technology such as cloud computing and virtualisation technologies (Khayer *et al.*, 2020).

Organisations rely on legacy systems to deliver critical functionalities to clients, however, to continue providing quality service to align with digital transformation, these systems need to be optimised through modernisation (Fanelli *et al.,* 2016). Legacy information systems are crucial organisational assets because of the key processes and functionalities that they carry throughout the life of the organisation (ibid). However, the systems should be updated and modernised to reflect new technology and evolving business practices. Moscoso-Zea *et al.* (2019) state that technology changes rapidly, therefore, organisations should adapt, to handle the inherent challenges that arise in this highly competitive market.

The modernisation of computer applications by moving to cloud platforms is a key driver for companies (Jamshidi *et al.*, 2013), as it refreshes legacy systems and enables organisations to continue providing optimum digital client service. To remain competitive and capable of meeting their business objectives, major and small to medium IT enterprises consider AM as a strategic priority (ibid). EA enables modernisation initiatives by ensuring alignment between business objectives, technology strategies, and transformation. Consequently, the relationship between EA, CM, and AM forms the conceptual foundation of this study. Figure 4 illustrates the relationship between these concepts. There are several organisations that rely on legacy systems to support essential business processes that cannot be easily changed, irrespective of maintainability issues (Zhou, 2014).

The process of modernising applications through CM includes analysis of security specifications, design and implementation (Bakar *et al.*, 2019). According to Khan *et al.,* (2023), the emergence of cloud adoption started in 2006 and by 2011 it had become the highest technology priority for organisations. Further, the adoption of cloud computing offers significant benefits to organisations, notably cost reduction. The modernisation of applications is motivated by an organisation's ambition to remain competitive and agile to changes at minimal cost (Fanelli *et al.*, 2016). However, due to lack of knowledge of cloud computing, most organisations are unable to implement the complex amendments that enable in-house applications to derive the optimum benefits of the cloud environment, therefore, it is critical to engage personnel with the needful skillsets (Chang, 2015).

Chapter 1 section 1.1 defines the key concepts of the study. Section 1.2 introduced the background of the problem, while the problem statement was presented in section 1.3. The research questions and sub-questions were discussed in sections 1.4 and 1.4.1, respectively. The research goals and objectives were stated in section 1.5. Research boundaries and exclusions forms part of section 1.6. Finally, the structure of the dissertation was depicted in section 1.7. Figure 1 is a Chapter map that depicts the content of Chapter 1.

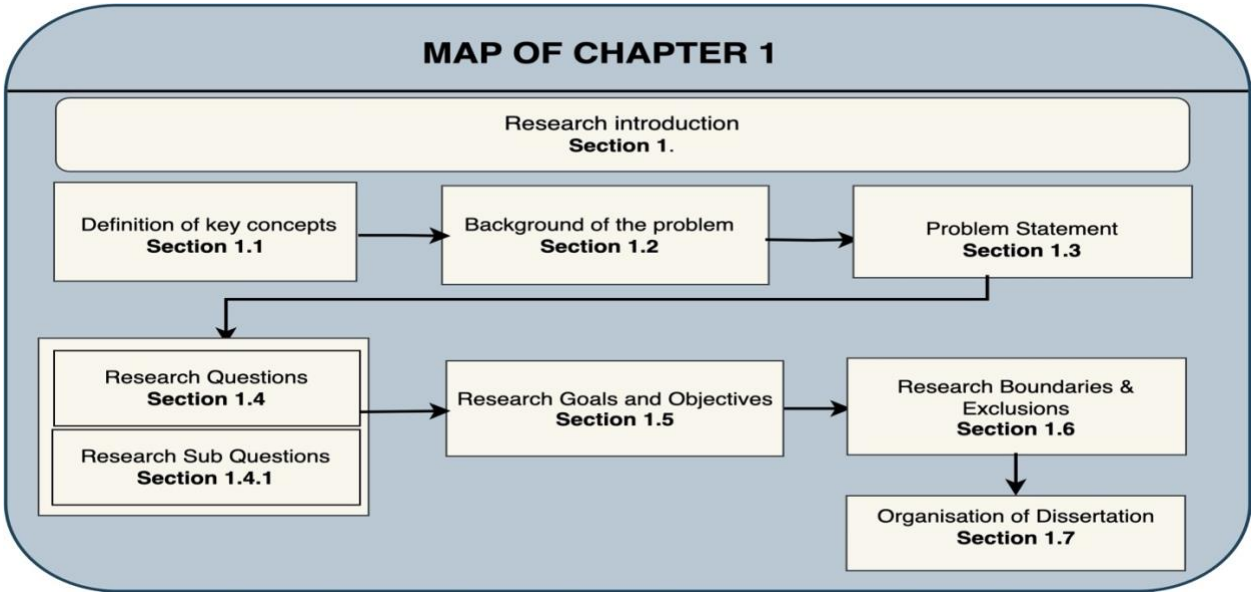

Figure 1 Map of Chapter 1

1.1 Definition of key concepts

1.1.1 EA

EA is a discipline that enables alignment between business objectives ,processes, information and technology to support organisational strategy and transformation (The Open Group, 2022; Tamm et al., 2022**).**

1.1.2 CM

CM refers to the process of moving applications ,data and associated components from on-premises environments to cloud-based platforms (Jamshidi et al., 2013; Ahmad & Babar, 2014**).**

1.1.3 AM

AM involves transformation of legacy applications to improve agility ,scalability, maintainability and alignment with modern business and technology requirements (Erder & Pureur, 2016; Abu Bakar & Razali, 2019**).**

1.1.4 ACMF

The ACMF refers to the EA-driven framework proposed in the study to facilitate CM in support of AM. A detailed discussion of these concepts is provided in chapter 2.

1.2 Background to the problem

Modernisation has been researched from a software perspective, which mainly focuses on technical solutions as means of enabling the processes of modernisation (Khadka *et al.*, 2015). Supplementary to the above statement, there seems to be inadequate research on the implementation of modernisation of applications from an architectural perspective. Therefore, this research sought to fill that gap. Firstly, the role of architecture in AM was discussed and analysed through architectural lenses. Therefore, it is important for academic communities to expand their knowledge of cloud computing by understanding the use of cloud services as a form of AM. The lack of a standardised approach for migrating to cloud is a concern that needs to be addressed. Labes *et al.* (2012) also mention that there were various service providers who were utilising different cloud software such as proprietary interfaces. Irrespective of its cost saving, scalability and flexibility, the absence of a standardised approach is the biggest challenge to the adoption of the cloud paradigm (ibid).

1.3 Problem statement

Organisations are modernising applications by adopting and migrating to cloud platforms, however, the process does not follow any standard framework (Ahmad *et al*., 2014). Literature has revealed that there are some concerns about this gap. Although migrating to cloud brings immense benefits, its biggest challenge is the absence of a uniform architectural framework which is suitable for the implementation of enterprise cloud (Zhou, 2014). Consequently, each organisation resorts to using an approach that best suits its requirements (ibid).

CM research has been growing significantly, yet the existing frameworks largely focused on the operational, financial and procedural factors, thereby typically lacking the integration of architectural considerations for AM (Hasan, 2023). EA is widely acknowledged as a strategic discipline that helps organisational transformation and aligns business strategy with information technology (The Open Group, 2022; Ross et al., 2006). Although previous studies have explored CM strategies, legacy AM, and EA as separate research domains (Jamshidi, et al., 2013; Erder & Pureur, 2016), there remains limited research integrating EA as the primary strategic and governance approach for enabling AM within the broader context of digital transformation. Furthermore, the literature does not provide a comprehensive, empirically informed EA-driven framework that integrates strategic alignment, governance, AM, integration, and continuous improvement into a unified approach.

This academic knowledge gap limits both the theoretical understanding and practical application of EA in guiding cloud-enabled AM initiatives. Consequently, organisations lack a structured EA approach that supports consistent governance, business technology alignment, and informed architectural decision-making throughout the AM lifecycle.

This study identified the lack of a comprehensive framework that incorporates architecture aspects into CM as one of the most significant challenges to CM. As a form of AM, CM is a crucial task in the context of digital transformation, however, organisations still need guidance to eliminate instances of failure during the implementation process (Khayer *et al*., 2020). The problem that will be addressed by this research is the lack of a

comprehensive framework that can integrate architectural considerations into CM to modernise applications. The research used architectural lenses to discuss CM. The researcher used CM as a form of modernising applications, therefore, the study sought to address the question of how to migrate to cloud architecturally in the process of modernising an application (Labes *et al*., 2012).

Frameworks such as Microsoft Cloud Adoption and Amazon AWS Cloud Adoption were exclusively designed for their respective cloud platforms, yet they cannot address all the aspects of CM. To cater to the needs of organisations that seek to migrate to cloud, employing a more comprehensive framework that encompasses multiple cloud platforms, strategies and best practices would prove advantageous.

1.4 Research question

What is required for a framework to enable the facilitation of CM for AM supported by EA?

1.4.1 Research Sub Questions

1. How do the three concepts (EA, CM, and AM) align?
2. What is the status quo of existing CM frameworks?
3. What are the pre- and core-requisites for CM?
4. What metrics are used to determine the success of CM?

1.5 Research goals and objectives

This research study creates an awareness of AM. Previous research on AM primarily focused on technical perspectives, notably rewriting source code to modernise solutions. Fanelli *et al*. (2016a) investigated the modernisation of legacy application through systematic strategy, with the study mainly focusing application code, information system and infrastructure as distinct objects that could be modernised separately. Unfortunately, the study did not allude to the use of any comprehensive framework to enable modernisation. Ahmad *et al*. (2014) researched the process-driven approach for CM, with a focus on migration of legacy application to service-oriented and cloud. The study found that there was lack of support for migrating legacy applications (ibid).

The need to investigate the lack of a comprehensive framework for defining and streamlining the CM process arises from a variety of reasons that were highlighted in industry dialogues, which include achieving business growth, technological advancements, transitioning from data centres and additional factors (Ramchand *et al*., 2021). The primary goal of this study is to develop and evaluate an EA-driven CM framework that supports the modernisation of legacy applications and guides organisations in planning and executing CM initiatives. Ahmad *et al*. (2014) indicated that organisations regard migration to cloud as a significant business strategy for modernising legacy applications. As a result, organisations require an integrated cohesive framework to cater for the technical and business aspects of modernising old systems (Abu Bakar *et al*., 2019).

The study sought to achieve the following objectives:

1. To investigate the relationship between (EA, CM, and AM) and examine how they are linked.
2. To identify limitations of existing CM frameworks.
3. To understand the status quo of the existing CM frameworks, as well as the pre- and core-requisites of CM.
4. To investigate the metrics that can be used to determine the effectiveness of CM.
5. To develop a comprehensive framework to facilitate CM.
6. To evaluate the proposed framework using experts.

1.6 Research boundaries and exclusions

This study investigates the role of EA in enabling AM within the context of digital transformation. The research is bounded by the following considerations:

- The application of EA principles, governance, and strategic alignment to support AM.
- Relationship between EA, CM and AM within the context of digital transformation
- The development of an EA-driven framework for AM.
- The study investigates CM from a strategic, architectural, and governance perspective rather than from a purely technical implementation perspective.

- Legacy applications undergoing modernisation within organisational digital transformation initiatives.
- Perspectives obtained from experts in cloud computing, EA, and related architecture practitioners through empirical data collection.
- The components of the proposed framework incorporates technological architecture, business strategy, governance and continuous improvement.

The study does not include:

- The technical deployment or execution of cloud platforms, including specific migration protocols, coding standards, or infrastructure setup.
- comparative analyses of particular cloud service providers, such as Google Cloud Platform, Microsoft Azure, or AWS
- financial modelling, cost-benefit analysis, or return-on-investment computations for CM projects.
- frameworks for implementing cybersecurity, network security, or cloud security.
- The creation, implementation, and testing of CM tools or software solutions are not covered by the research.
- Investigations centred on organisational change initiatives, human resource management, or user adoption approaches were excluded from the review
- Validation of the proposed framework through implementation in multiple organisations, as the study focuses on framework development informed by literature and empirical evidence.
- The proposed framework was not validated through implementation in a live organisational environment; instead, validation was conducted through expert evaluation.

1.7 Organisation of the dissertation

Chapter 1 comprises the introduction and background of the study, and Chapter 2 outlined the review of literature. Chapter 3 illustrates the discussion of the methodology used for this research. Chapter 4 illustrated and evaluated the development of the proposed framework. Chapter 5 presented and analysed the data and findings. Finally,

Chapter 6 presented the conclusion, summary and recommendations of the study. The dissertation map in Figure 2 provides a depiction of the Chapter progression.

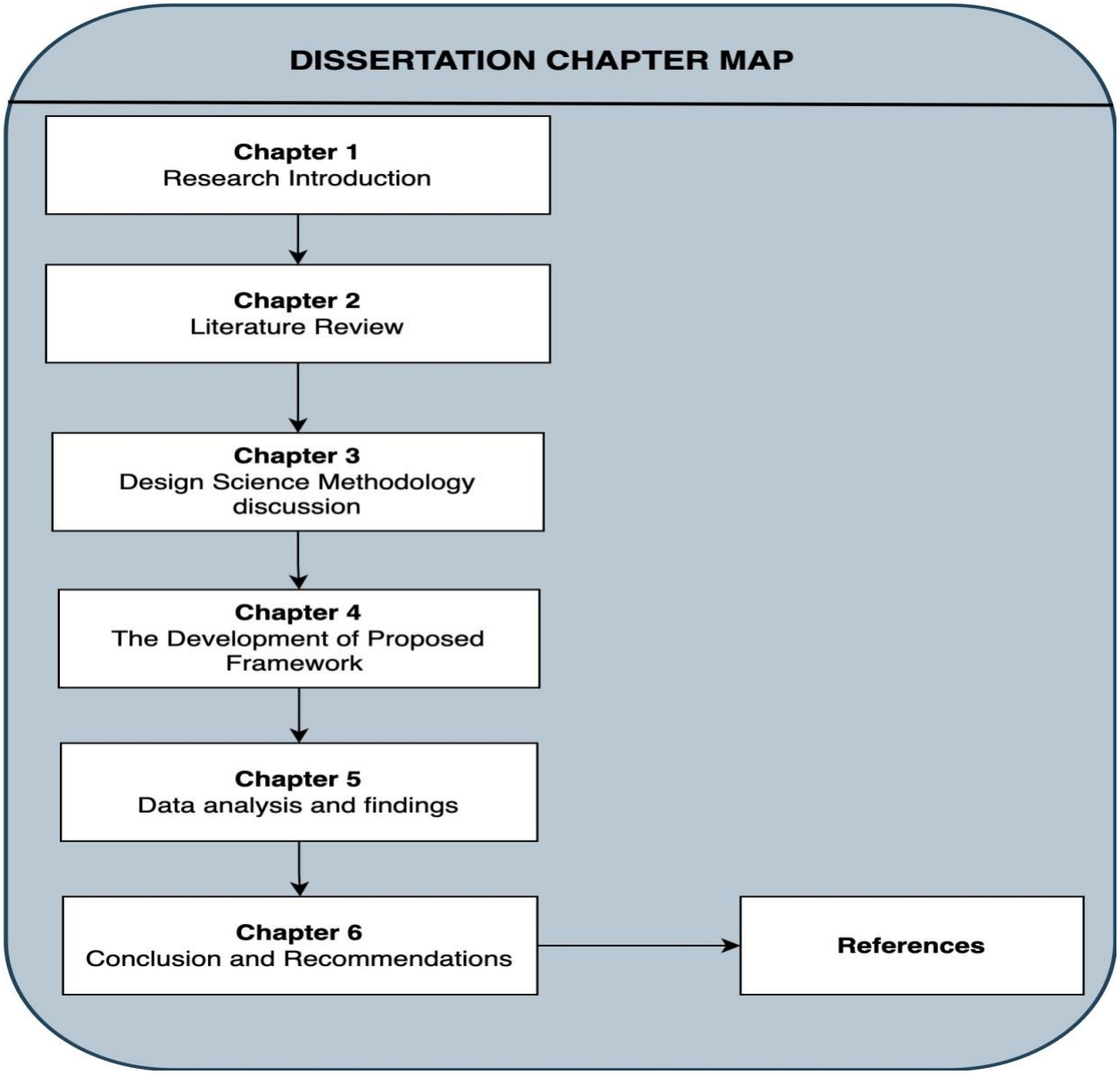

Figure 2 Dissertation map

2 Literature Review

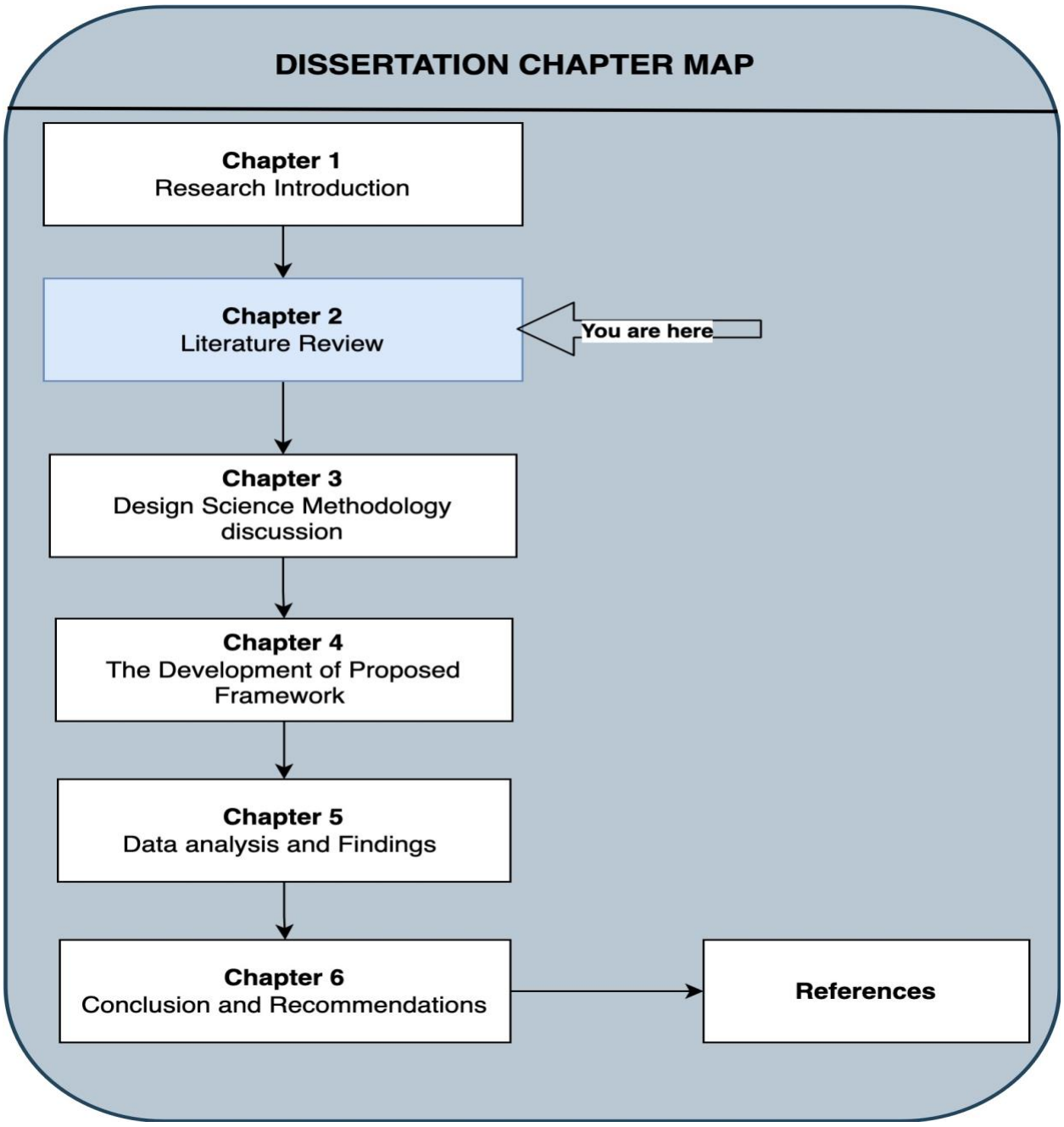

Figure 3 The dissertation map

The above Figure 3 depicts a demonstrative presentation of how the chapters in this document are structured.

2.1 Introduction

The focus in this chapter delves into the relationship between AM ,EA and CM , as presented in Figure 4. The chapter includes a review of the literature related to each concepts and investigates their interdependencies within transformation initiatives. The analysis of existing migration frameworks is conducted, identifying limitations as well as examining the role of EA in CM and AM initiatives. Although some of the referenced studies are more than a decade old, they have been included where appropriate because they represent seminal contributions that shaped foundational concepts and principles of EA, CM, and AM research.

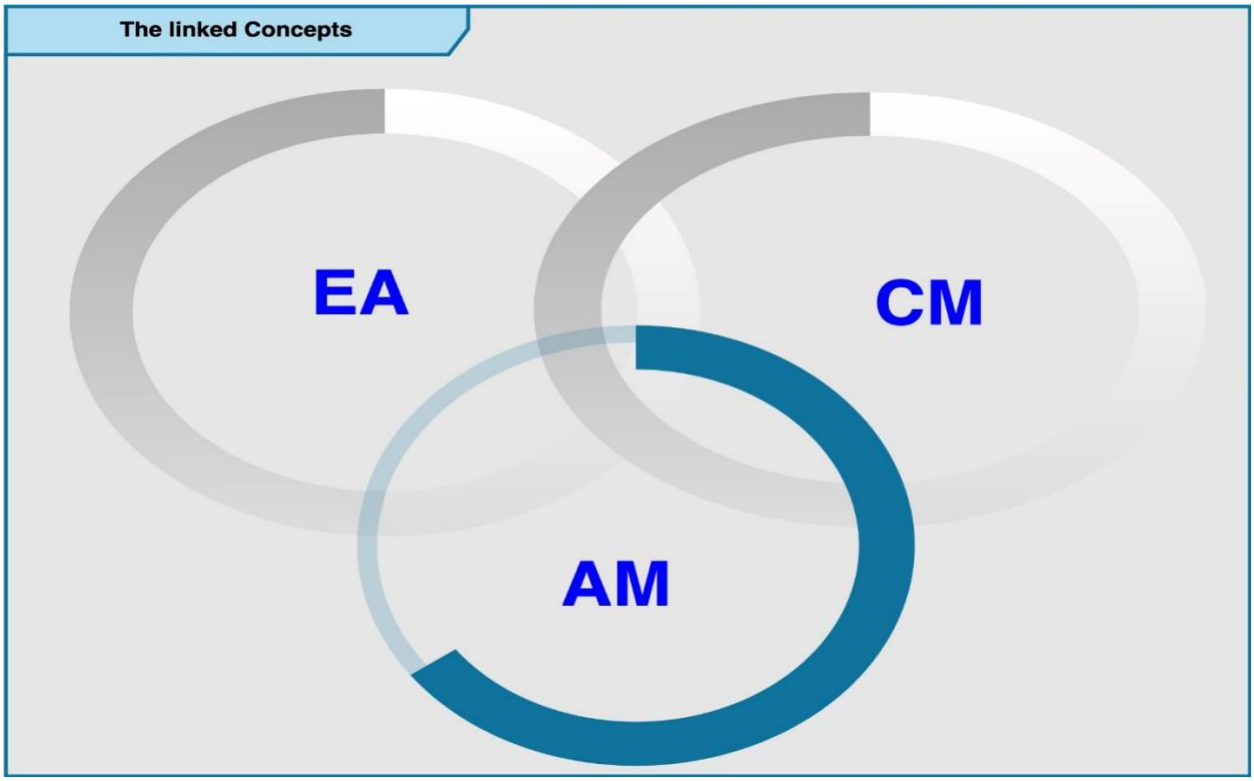

Figure 4 Core linked concepts (collated by the researcher)

As shown in Figure 4. AM is defined as the process of updating and transforming existing software applications to enhance the functionality, performance, and user experience, while aligning the application with contemporary technological standards (Santikarama & Arman, 2016). EA and CM are two critical components in the realm of modernisation within the information technology (IT) sector, because both provide a baseline to handle uncertainty and effectiveness of modernisation (Alghamdi, 2024).As organisations strive

to adapt to rapidly evolving technological landscapes through AM, understanding the significance of EA in facilitating successful CM is paramount (Ardiansyah, J, 2023) (Ardiansyah, 2023).Figure 4 depicts how the three concepts are linked. EA is a strategic consideration for organisations because it plays a critical role in ensuring that the risk associated to migration efforts is managed by ensuring that all systems are architecturally defined prior to embarking on the migration journey (Alghamdi, 2024).

EA enables organisations to plan effectively before migration by considering architecture models and technology needs (ibid). While organisations modernise systems through CM, it is imperative to use EA to create a blueprint that ensures that there are no changes in the architecture models and the use of technology (Prakash, 2025).This Chapter compared existing CM frameworks, as presented in the literature, to understand the baseline and the status quo of the frameworks. The following frameworks are included in the comparison to identify the gaps in the frameworks: The Cloud Adoption Framework for Azure by Microsoft, AWS CAF by Amazon, CMAF by McKinsey and The Gartner Five R Framework. The map for the rest of the chapter is depicted in Figure 5.

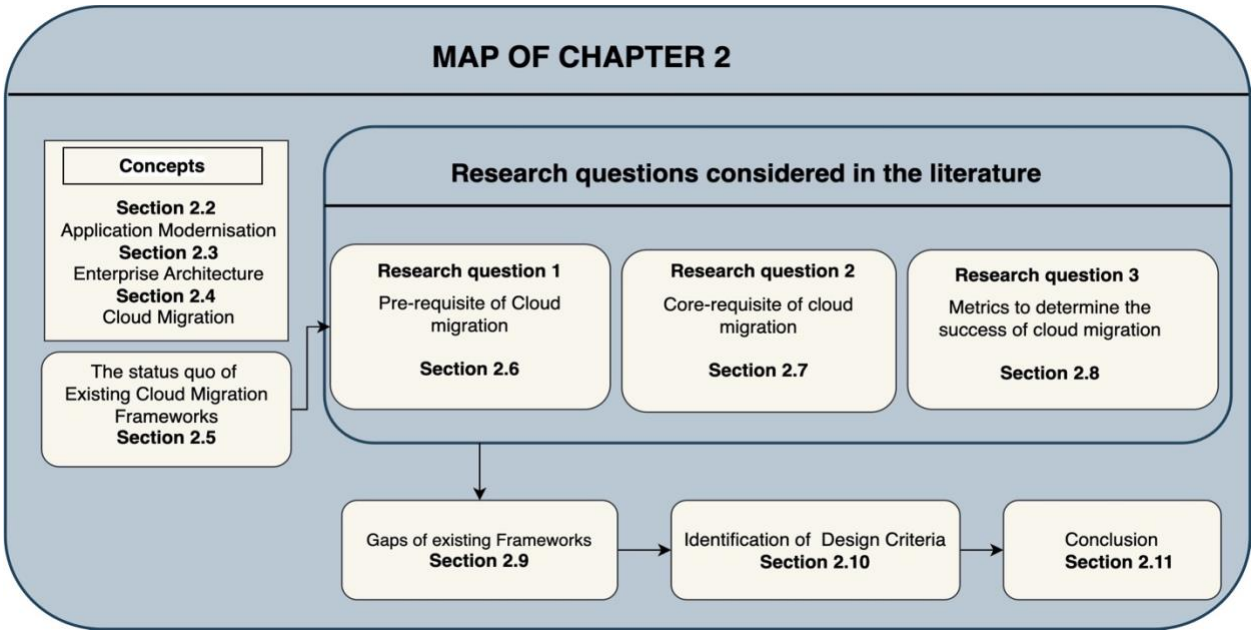

Figure 5 Map of Chapter 2

2.2 AM

The concept of AM originates from the inception phases of computing, when organisations realised the need to update existing legacy systems to meet the evolving business requirements (Settu *et al*., 2013). The origins of AM lie in the challenges that organisations face when as seeking to update existing applications to modern technologies and architectures (IBM, 2023). The process of optimising the legacy application is called AM (Setiawan, 2020). Extant research on software modernisation focuses on technical solutions as facilitators of modernising application (Ponnusamy & Eswararaj, 2023). AM is a process of refreshing existing legacy applications by modernising the infrastructure, architecture, and related features (IBM, 2019). Most of legacy applications are monolithic, meaning the application components are integrated and coupled together (ibid). Monolithic applications can be modernised to multiple smaller and loosely coupled components and micro service architecture, which can be deployed separately from one another (Deshpande *&* Singh,2020). Fanelli *et al*., (2016) conducted research on the modernisation of legacy applications. However, the study focuses more on enhancement of the application code, since applications are deemed as legacy because they contain outdated software and complex programming code.

An organisation's enthusiasm to modernise applications determines its desire to remain competitive and agile to change, as well as save operational costs (Pijuan, et al., 2019). Another form of modernisation is software re-engineering, which enhances maintainability and functionalities of legacy application through the implementation of modern technologies and processes (Tarride, 2022). Software modernisations change the components of a legacy system to a state where it can provide the best client service.
In most cases, when clients start experiencing slow responses, as system features take too long to render on the interface, the root cause might be emanating from the old infrastructure, which might be struggling to handle to load (Ardiansyah, 2023). Cloud computing has transformed the traditional application development and deployment processes, and it has offered organisations a scalable and cost-effective solution for hosting their applications without the need for extensive on-premises infrastructure (Netinant *et al*., 2023). Thus, this shift towards cloud-based solutions has paved the way

for greater flexibility and agility in application development, making it easier for businesses to adapt to changing market conditions (Apeh *et al*., 2023).

According to Ardiansyah (2023), one of the key drivers behind the need for AM is the increasing demand for digital transformation among organisations. For the businesses to remain competitive in the rapid growing digital economy, they are required to update their legacy applications to leverage new technologies such as IoT and big data analytics (Bandari, 2022). Modernising applications allows companies to enhance customer experiences, streamline operations, and drive innovation within their industries. According to Ponnusamy and Eswararaj (2023), modernising applications during CM offers several benefits for organisations that intend to optimise their IT infrastructure. By migrating legacy applications to cloud platforms, businesses can achieve greater scalability, reliability, and security, while reducing operational costs (Watson, 2020). Cloud-based solutions facilitate rapid time-to-market for new digital capabilities, thereby enabling the competitiveness of the organisation in the current evolving market (Alharbi, Ibrahem, Moussa, Abdelwahab & Diab, 2022).

2.3 EA

The concept of EA helps organisations to maintain competitive advantage by providing fundamentals for the implementation of various strategies (Tamm *et al*, 2022). EA has been shaped by several foundational frameworks, notably the Zachman Framework and The Open Group Architecture Framework (TOGAF). The Zachman Framework, which was first presented by Zachman in 1987, offers an organised classification for classifying architectural products from the viewpoints of various stakeholders and is now a key point of reference for EA practice and study. TOGAF also offers a thorough methodology for creating, executing, and regulating EA, with the architectural development method (ADM) acting as an organised strategy for coordinating business and technological goals The Open Group (2018). Although some of these frameworks were developed several years ago, they continue to influence contemporary EA research and are widely referenced in both academia and industry.

EA gradually evolved into multi-concept, as it interconnects concepts such as strategic alignment, service and process optimisation, and the development of systematic, standards-based solutions (Adenuga *et al*., 2015). Consequently, EA connects business, governance, and information systems management (ibid). The key elements for implementing and fostering innovation, while also promoting agility as well as responsiveness are accomplished through the EA concept, because it integrates cross-domain requirements into an integral flexible architecture that promotes interoperability in organisations (Nsaghurwe *et al*., 2021).

2.4 CM

CM is the concept of migrating IT systems from on-premises servers to the cloud (Ahmad *et al*., 2014). CM includes a sequence of tasks that are executed to migrate a system to cloud environment (Chang *et al*., 2015). According to Zhou (2014), the migration of systems is a process of changing from one operating environment to another. Organisations are taking advantage of CM and retaining the investment of their legacy system, by implementing the migration of legacy systems to the cloud (Jadeja, 2012).
The migration of software is a significant journey, which deals with enhancement for a completely new setting (Jamshidi *et al*., 2013). Pahl (2013) defines CM as a deployment of digital resources, facilities, IT applications to the cloud. CM is considered as an *adaptive evolution* and software architecture concept for migrating legacy systems to cloud-enabled software (Behl, 2011). CM is a process which involves analyses, re-factoring, and re-engineering operations to sustain the move from on-premises to cloud, and it defines an inclusive perception, while taking consideration of business and technical concerns (Charlebois *et al*., 2016). The concept and definition of CM has been well-researched and discussed in the body of knowledge, however, this research will expand the knowledge of CM as a form of AM, as well as discuss it from an architectural point of view.

2.5 The status quo of existing CM frameworks

The initial stages of CM frameworks can be traced back to the emergence of cloud computing as a disruptive technology paradigm. In the emerging stages of CM

frameworks, organisations faced security challenges and uncertainties about cost-effectiveness when considering migrating to the cloud (Jeong *et al.,* 2019). As organisations began embracing CM models, there was a growing need for robust frameworks that could streamline the migration process (Jones *et al*., 2019). The evolution of CM frameworks has been shaped by rapid advancements in technologies such as virtualisation, containerisation, automation tools, and artificial intelligence (Ponnusamy & Eswararaj, 2023).

These advancements have empowered organisations with greater flexibility, scalability, and efficiency in managing their cloud environments. Modern-day frameworks leverage innovative solutions like DevOps practices, micro services architectures and serverless computing models to enhance agility and optimise resource utilisation during migrations (Amaro *et al*., 2024).Statistical evidence reveals an upward trajectory in the growth and adoption of CM over time. According to research by Gartner, the globe public cloud earnings was estimated to incline by 18% in 2021 alone (Hosseini et al., 2022). The manufacturing sector leads in cloud adoption with 45%, followed closely by healthcare at 41%. Geographically, North America dominates the market share at 59%, with Europe trailing at 24% (ibid). These statistics underscore the increasing reliance on cloud technologies across various industries and regions. Organisations stand to benefit significantly from migrating to the cloud. Statistical evidence demonstrates improvements in efficiency through streamlined processes and enhanced collaboration among the teams that are dispersed across different locations (Bandari, 2022). Another key advantage of deploying CM strategies, as highlighted by research findings, is that it can reduce the operational costs of a company by up to 30% (Ponnusamy & Eswararaj, 2023).

2.5.1 Cloud adoption framework

The paradigm of computer service delivery and IT applications processing has shifted from in-house hosting to cloud environment, that has a profound impact on modern architectural practices (Laaber *et al*., 2019). Architects now have access to scalable resources, enhanced collaboration tools, and cutting-edge technology such as AI and tools for analysing data that can transform their design processes (Ponnusamy & Eswararaj, 2023). The CAF is essential for guiding architects through the complexities of

transitioning to cloud-based solutions. By providing a structured methodology for planning, implementing, and managing cloud initiatives, this framework ensures that architectural projects harness the maximum capability of cloud computing, while reducing associated risk and optimising costs (Zbořil & Svatá, 2022). Without such guidance, architects may struggle to navigate the intricacies of cloud adoption and fail to realise its benefits fully.

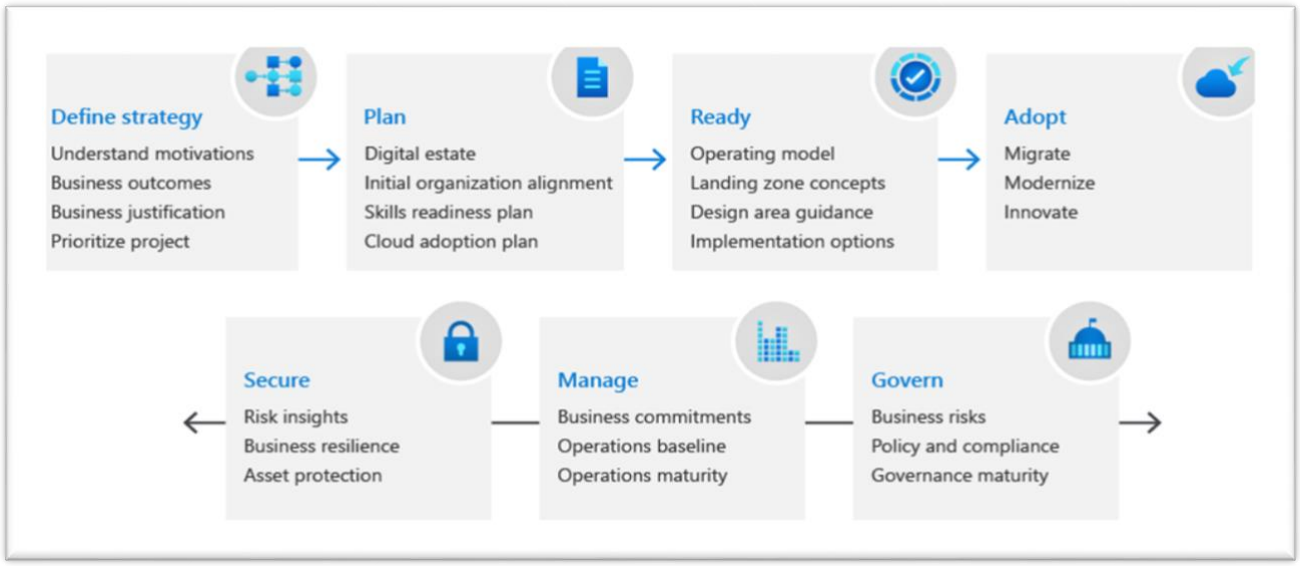

Figure 6 The Cloud Adoption Framework (Microsoft, 2025)

As depicted in Figure 6, integrating The Cloud Adoption Framework with EA practices is essential, because it ensures seamless cloud adoption within an organisation. By aligning technical requirements with business needs through effective planning and governance structures, businesses can maximise the benefits of migrating to the cloud (Staunton *et al*., 2021). The structured framework provided by the CAF in Figure 6 facilitates collaboration between different stakeholders who were involved in the migration process, leading to more successful outcomes. As shown in Figure 6, the following aspects are included in the cloud adoption framework:

2.5.1.1 Define strategy

Before embarking on the cloud adoption journey, it is paramount to have a well-defined strategy, as it not only sets the direction for the organisation, but it also ensures that business goals are aligned with the intended outcomes of cloud adoption (Jeong *et al*.,

2019). When organisations understand why they are moving to the cloud and what they aim to achieve, they can make informed decisions that can drive value and growth.

2.5.1.2 Plan

The planning phase of The Cloud Adoption Framework involves meticulous consideration of numerous factors such as current infrastructure, budget constraints, regulatory requirements, and workforce readiness (Lei *et al*., 2019). Organisations should ensure that they can develop detailed plans that outline timelines, milestones, resource allocations, and risk management strategies, to navigate the complexities of migrating to the cloud successfully.

2.5.1.3 Ready

Readiness assessment is a critical aspect of preparing for cloud adoption. Therefore, organisations need to evaluate their existing capabilities, skills gaps, security protocols, and scalability requirements, to ensure a smooth transition to the cloud environment (Bandari, 2022). By identifying potential challenges early on and addressing them proactively, organisations can mitigate risks and optimise their operations post-migration.

2.5.1.4 Adopt

In the adoption phase, best practices play a crucial role in implementing cloud technologies effectively. From selecting suitable service models and deployment options to managing change within the organisation, adherence to proven methodologies can facilitate a seamless transition and maximise benefits from cloud adoption initiatives (Ponnusamy & Eswararaj, 2023).

2.5.1.5 Secure

When it comes to operating in a cloud environment, security is a fundamental consideration. With data breaches becoming increasingly common, it is critical for organisations to implement stringent security protocols to protect personal information, while adhering to industry regulations (Ramchand *et al*., 2021). Implementing encryption protocols, access controls, monitoring tools, and regular audits are some of the most essential components of an effective security strategy in the cloud.

2.5.1.6 Manage

Effective management of resources is vital for optimising costs and performance in a cloud setting. Organisations must continuously monitor usage metrics, analyse trends, implement automation, where possible, and scale resources according to demand fluctuations (Bandari, 2022). The adoption of agile management practices that are tailored for the dynamic nature of cloud environments, can enhance operational efficiency in organisations, while also controlling expenditures effectively.

2.5.1.7 Govern

Governance frameworks provide the structure and oversight that are necessary for maintaining control over various aspects of cloud services utilisation within an organisation (Tarride, 2022). From establishing policies for data governance and user access permissions to monitoring service level agreements (SLAs) with vendors closely, governance mechanisms help to ensure accountability and transparency throughout all the stages - from planning through to implementation - into ongoing operations post-adoption (Wakefield *at al*., 2024).

The success of a CM project depends heavily on following the best practices that are recommended by The Cloud Adoption Framework, which include conducting thorough assessments of existing systems, defining clear objectives for migration efforts, prioritising security considerations throughout the process, and implementing robust monitoring mechanisms post-migration (Ardiansyah, 2023). Organisations must also proactively address challenges such as data transfer issues, compatibility concerns, and staff training requirements during migration initiatives.

2.5.2 AWS Cloud Adoption Framework

The AWS CAF encompasses a set of best practices and guidelines that are designed to help organisations to adopt cloud technologies successfully. The framework consists of six core aspects as depicted of Figure 7 (Zbořil & Svatá, 2022). Each aspect addresses specific areas that are essential for a holistic cloud adoption strategy. By following this framework, organisations can systematically plan and execute their transition to the cloud, thereby maximising the value derived from their investments (Staunton *et al*., 2021).

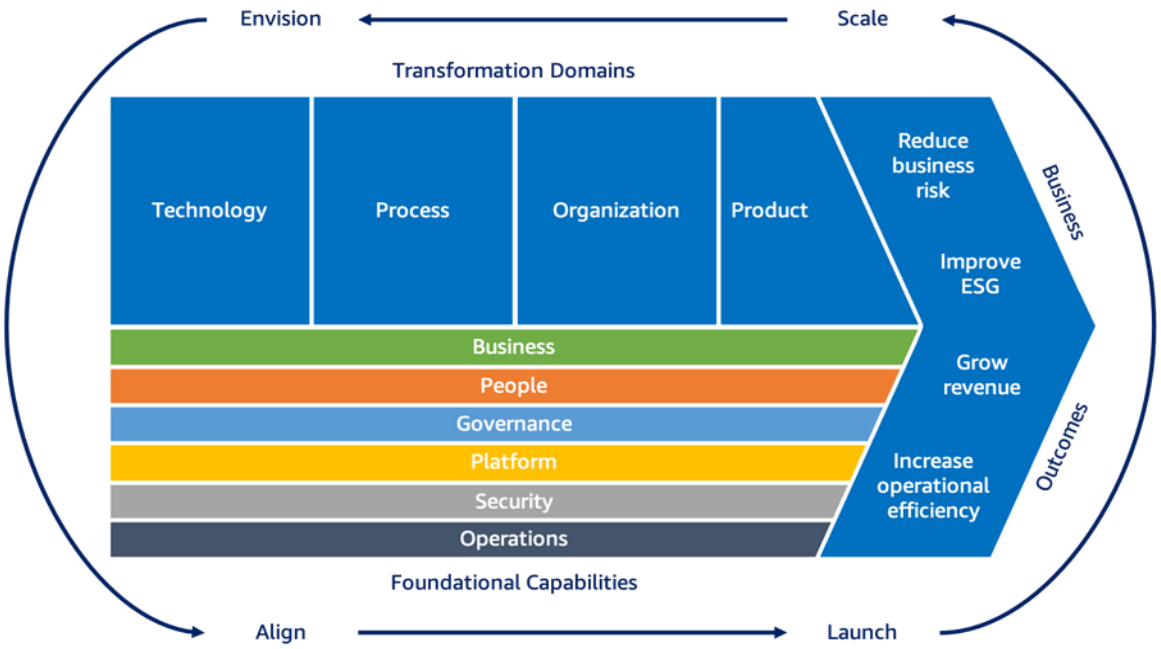

Figure 7 AWS Cloud Adoption Framework *(Amazon, 2021)*

Figure 7 depicts the core components of AWS adoption framework and how organisations leverage on the migration approach. At the planning stage of adopting the AWS Cloud Adoption Framework, organisations are required to assess their readiness for CM. This involves evaluating factors such as existing infrastructure, skills gaps within the workforce, and potential challenges that may arise during the transition process (Bommadevara *et al*., 2018). Additionally, defining clear business objectives is crucial for enabling stakeholder alignment on the expected outcomes of adopting cloud technologies. Developing a robust business case is paramount for gaining support from key decision-makers within an organisation (Hosseini *et al*., 2022).

The process involves conducting a cost-benefit analysis that considers factors such as continuous operational expenditure, costs related to initial investment and expected financial gains (ROI) (Ramchand *et al*., 2021). By highlighting how adopting the AWS Cloud Adoption Framework can drive cost savings and improve operational efficiency over time, organisations can make a compelling case for transitioning to the cloud (Gholami *et al.,* 2016).Governance implementation post-adoption is essential for ensuring that compliance with industry regulations is maintained, including security practices within cloud environments.

Organisations must establish policies and procedures that govern how resources are provisioned, managed, and monitored in alignment with best practices outlined in the framework (Ardiansyah, 2023). The implementation of stringent governance mechanisms enables organisations to mitigate the risks that are associated with unauthorised access or data breaches in the cloud. In the post-adoption phase, operations management entails regular monitoring of performance metrics, in order to optimise resource utilisation and manage costs effectively (Banimfreg, 2023).

By leveraging tools like Amazon, Cloud Watch and AWS Cost Explorer, which are provided by AWS, organisations can gain insights into how their cloud environments performs and identifying optimisation opportunities (Khan & Salah, 2020). Moreover, by establishing clear roles and responsibilities among the team members who are involved in managing day-to-day operations, organisations can effectively foster accountability across all levels. Technology plays a pivotal role in enabling successful implementation of the AWS CAF within an organisation's infrastructure. Infrastructure considerations such as scalability, reliability, and performance optimisation are critical factors that need careful assessment before workloads are migrated to the cloud (Banimfreg, 2023).

To achieve the desired outcomes efficiently, it is essential for organisations to select the appropriate Amazon Web Services menu, based on specific use cases (Hosseini *et al*., 2022). Security remains paramount within the context of adopting the AWS CAF framework, due to increasing cyber threats and the regulatory requirements that govern data protection practices globally (Chang *et al*., 2014). Organisations must prioritise security measures that encompass data encryption protocols, compliance standards adherence, and risk management frameworks, among others, when transitioning sensitive workloads to public or hybrid clouds (Tarride, 2022). Incorporating robust security mechanisms from inception stages onwards ensures that data integrity remains intact throughout the various stages of operation within Amazon Web Services ecosystem (Setiawan, 2020).

2.5.3 Cloud Migration Assessment Framework (CMAF)

The CMAF was designed by McKinsey to enable organisations to evaluate their readiness and suitability for successfully migrating to the cloud (Bommadevara *et al*., 2018). By providing a structured approach and set of guidelines, CMAF aims to streamline the assessment process and identify the key areas that require attention, before initiating any migration activities (Phadnis, 2022).

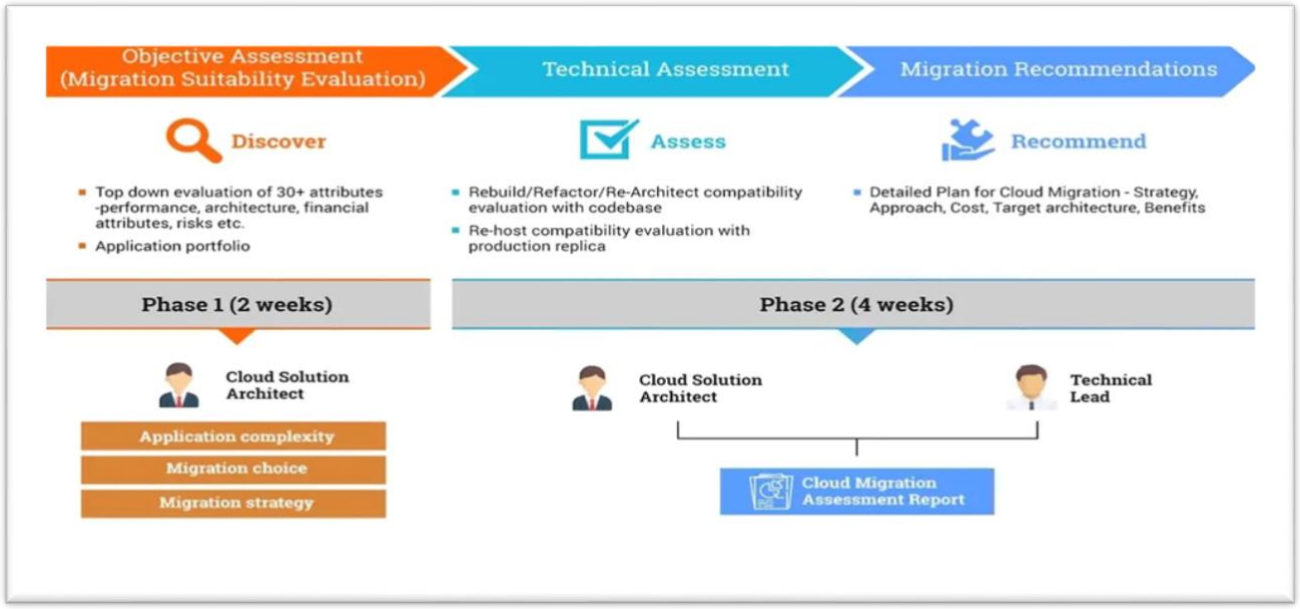

Figure 8 Cloud Migration Assessment Framework *(eInfochips, n.d.)*

Figure 8 presents the components of CMAF including objective assessment, technical assessment, and migration recommendations. Migration suitability evaluation involves assessing the readiness of applications for migration based on predefined criteria such as complexity, dependencies, regulatory requirements, performance metrics, security considerations, and scalability needs (Alonso *et al.,*2013). This process helps organisations to identify suitable applications for migration to the cloud, based on their compatibility with cloud-native features and functionalities (Bommadevara et al., 2018). Application portfolio analysis is a significant aspect of CMAF that prioritise the categorisation of applications, based on their business value, technical requirements, interdependencies, maintenance costs, and strategic alignment with organisational goals (Setiawan, 2020).

By conducting a thorough analysis of the application portfolio, organisations can identify redundant systems, legacy applications requiring modernisation or retirement opportunities for consolidation (Jeong *et al.,* 2019).

Technical assessment in CM involves evaluating the technical aspects of existing technology infrastructure and systems to evaluate their ability for migration to the cloud (Rahman, 2019). This process helps organisations to identify the potential challenges and risks that may arise during migration, thereby allowing organisations to develop mitigation strategies accordingly (Gholami *et al*., 2016). Rebuilding applications during CM involves redesigning or redeveloping them using native cloud services or platforms. The process includes assessing factors such as application dependencies, performance requirements, scalability needs, and data storage mechanisms to ensure compatibility with the target cloud environment (Islam *et al.,* 2017). Refactoring applications entails making code changes or optimisations to enhance their compatibility with existing codebases or frameworks in the target cloud environment. This evaluation focuses on improving performance, security, and maintainability, while also ensuring seamless integration with other components (Banimfreg, 2023).

Re-architecting applications involves restructuring them based on micro services architecture or serverless computing paradigms to improve agility, scalability, and resilience in the cloud environment (Settu *et al*., 2013). Evaluating compatibility with existing codebases requires thorough analysis of interdependencies, communication protocols, data formats, and APIs (Hussein, 2021). Re-hosting applications refers to migrating them as-is, without any architecture amendments or codebase (Watson, 2020). Evaluating compatibility during re-hosting involves verifying system requirements, operating system dependencies, middleware configurations, network settings, and data storage options for seamless deployment in the target cloud platform (Bommadevara *et al*., 2018). (Jones *et al*., 2019) attest that migration recommendations are essential components of CMAF, as they provide detailed insights into how an organisation should approach its CM journey. These recommendations outline specific actions that need to be taken at each stage of the migration process (Weber-Lewerenz, 2021). By following these recommendations diligently, organisations can attain smooth and successful

transitions to the cloud. One significant aspect of Migration Recommendations is their role in helping organisations to assess their current infrastructure effectively (Santikarama & Arman, 2016). Before embarking on a CM journey, it is crucial for organisations to have a comprehensive understanding of their existing systems and infrastructure (Tarride, 2022). Migration Recommendations within CMAF guide organisations through this analysis phase, thereby helping them to determine whether their current setups are ready for migration or if any upgrades or modifications are required (Ardiansyah, 2023).

Migration recommendations assist organisations in identifying clear goals and objectives for the CM initiative. Setting realistic and achievable targets is essential for ensuring that the migration aligns with broader business objectives (Phadnis, 2022). By defining these goals within the framework provided by CMAF, organisations can stay focused throughout the migration process, and they would be able to measure their success against predetermined metrics. In addition to goal setting, Migration Recommendations also play a critical role in risk assessment and mitigation strategies (Lei *et al*., 2019). Moving operations to the cloud involves inherent risks such as data security concerns, potential downtime during transition phases, or compatibility issues with existing systems. Through conducting careful evaluation, as guided by CMAF's recommendations, organisations can proactively identify risks and develop robust mitigation strategies to address them effectively (Ardiansyah, 2023).

2.5.4 Gartner’s five “R” framework

Gartner’s five “R” framework is a strategic model that was developed in 2019 by Gartner Research, a renowned research and advisory company that specialises in technology trends. Organisations adopt these frameworks when planning their CM strategies (Gartner Research, 2019). Each "R" in the framework represents a different strategy, which is tailored to meet specific business objectives and technical requirements during the migration process. Over the years, Gartner Research has provided valuable insights into various aspects of information technology through its reports, consultations, and frameworks (SA Technologies, 2018). The development of the Five Rs Framework was influenced by the growing demand for structured approaches to facilitate successful CMs among enterprises that are facing diverse challenges such as legacy systems integration,

security concerns, and compliance issues (Watson, 2020). The first approach, Rehost (lift and shift), involves transferring existing systems and data without any architecture amendments (Gartner Research, 2019). The second approach, Refactor (re-architect), involves reimagining applications for better performance or scalability within the new cloud environment, while the third, Revise (revise for compatibility), focuses on modifying applications or processes to ensure compatibility with target platforms (SA Technologies, 2018). Furthermore, the fourth approach, Rebuild (rebuild for the cloud), requires redesigning applications using native cloud services for optimal performance. Finally, Replace (replace with SaaS), involves replacing on-premises software with Software-as-a-Service solutions available in the cloud (Watson, 2020).

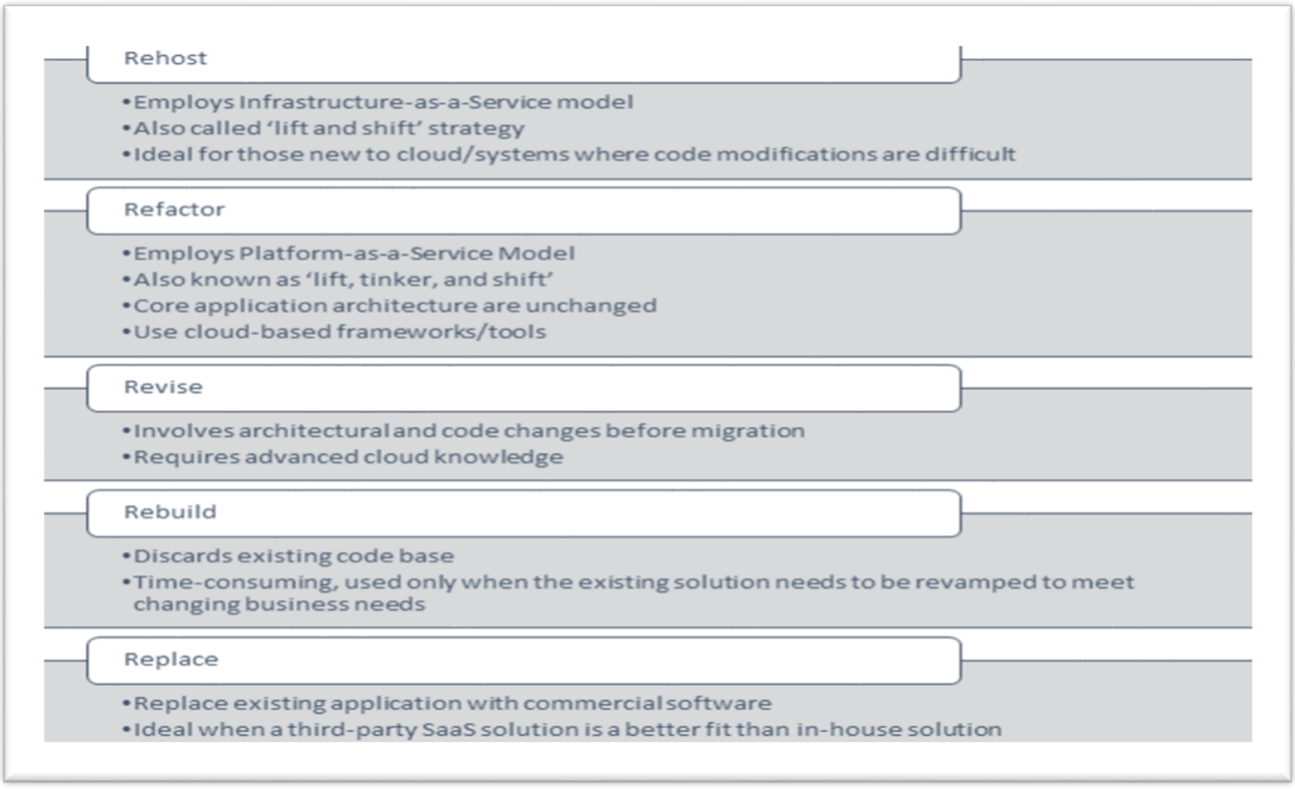

Figure 9 Gartner's 5-R Framework *(Khan, 2020)*

Organisations across diverse industries have embraced Gartner's Five R Framework as a roadmap towards successful CMs. Aligning the migration strategies with one or more "Rs" based on the unique business requirements allows organisations to streamline the transition to the cloud, enhance operational efficiency, and realise cost effectiveness (Gartner Research, 2019). While Gartner's five "R" framework provides invaluable

guidance for organisations that are embarking on CM journeys, there have been some criticism regarding its applicability across all scenarios (SA Technologies, 2018). One common limitation relates to the rigidity of the framework, which may not accommodate exceptional cases that require customised migration strategies (Watson, 2020).

2.6 Pre-requisites of CM

Before embarking on a CM journey, organisations must carefully assess various critical factors such as business objectives, to ensure smooth and successful transitions (Jones, 2019). Aligning the migration strategy with overarching business goals is paramount for driving value creation. Regulatory compliance ensures compliance with industry-specific regulations when handling sensitive data or information (Hosseini, Amin & Babaeikiadehi, 2022). Cost analysis is imperative in conducting a comprehensive cost-benefit analysis for evaluating the financial implications of migrating workloads to the cloud (Ardiansyah, 2023). Skill set assessment requires the assessment of internal skill sets and external expertise that are required to manage and optimise cloud-based architectures effectively.

2.6.1 Business objectives

Business objectives serve as guiding principles that direct decision-making within organisations. These objectives outline the goals which the organisation seek to accomplish to fulfil its mission and vision (Settu *et al*., 2013). When it comes to CMs, defining clear business objectives is paramount in ensuring that the migration strategy aligns with the overall strategic direction of the organisation (Ramchand *et al*., 2021). When defining business objectives for CMs, several key factors should be considered, and these include: understanding organisational needs and constraints; assessing current IT infrastructure capabilities; identifying potential risks and compliance requirements; setting measurable targets for performance improvement or cost reduction; and securing stakeholder buy-in across departments (Zbořil & Svatá, 2022).

2.6.2 Regulatory compliance

In the context of CM, when migrating operations or data to the cloud environment organisations are expected to ensure that they comply with regulations by adhering to established laws and data protection, privacy, and security standards (Apeh *et al*., 2023). Significant consequences such as financial penalties, legal issues, reputational harm, and a decline of trust from customers are the results of non-compliance with regulatory requirements (Santikarama & Arman, 2016). The importance of complying with regulators during CM cannot be overstated.

One of the most crucial aspects of regulatory compliance that must be fulfilled prior to undertaking CM is data security (Zbořil & Svatá, 2022). When organisations move their operations or data to the cloud, they need to ensure that there is adequate protection of sensitive information from potential threats or breaches. Complying with regulators provides guidelines and best practices that facilitate the protection of data that aligns with industry-specific regulations (Ardiansyah, 2023). Moreover, regulatory compliance also helps in maintaining transparency and accountability within organisations. By following the established regulations and standards that are related to data protection and privacy, businesses demonstrate their commitment towards ethical business practices (Gholami *et al*., 2016). This not only builds trust among customers, but it also enforces a culture of accountability within the organisation.

2.6.3 Data security

Data security is an essential consideration in cloud computing that focuses on protecting data from unauthorised access, disclosure, disruption, and modification. In the context of CMs, where data are stored and accessed over the internet on remote servers that are maintained by third-party providers, it is essential to enable effective data security capabilities to mitigate the risk of vulnerabilities (Alharbi, Ibrahem, Moussa, Abdelwahab & Diab, 2022). Proactive measures play a pivotal role in safeguarding sensitive information during CMs. By adopting effective data security methodologies in the cloud environment, organisations can enhance their cybersecurity postures significantly (Zbořil & Svatá, 2022). Some effective approaches include conducting regular employee training on cybersecurity awareness, implementing multi-factor authentication protocols,

encrypting data at rest and in transit, utilising structure industry programmatic process such as AES, deploying IDS and IPS, as well as leveraging SSL certificates for secure communication channels (Banimfreg, 2023; Ardiansyah, 2023).

2.6.4 Cost analysis

In the context of CM, cost analysis involves evaluating all relevant costs that are associated with moving applications, data, and infrastructure to the cloud (Hosseini Shirvani, Rahmani & Sahafi, 2018). This entails all direct costs, like subscription fees, as well as training employees in modern technologies. conducting a thorough cost analysis before initiating a CM project is critical, as it helps organisations to estimate expenses accurately and allocate resources effectively (Ramchand *et al*., 2021). According to Ozyurt *et al*. (2022), several key factors need to be considered when performing a cost analysis for CM. These factors include: initial setup costs; ongoing operational expenses; data transfer fees; performance optimisation requirements; costs for implementing security measures; and compliance needs impact on pricing structures from different service providers (Ozyurt *et al.,* 2022). Each factor can significantly influence the overall cost and success of the migration project; therefore, meticulous consideration is necessary (Bandari, 2022).

Various tools and methods are available for organisations to conduct a comprehensive cost analysis before migrating to the cloud (Hurwitz & Kirsch, 2020). Some commonly used approaches include Total Cost of Ownership (TCO) calculators, which are provided by cloud service providers or third-party vendors that help to estimate long-term expenditures accurately, based on specific requirements and usage patterns (Karthikeyan *et al*., 2020). Performing a thorough cost analysis before migrating to the cloud provides various benefits for organisations (ibid). It enables them to optimise resources efficiently by identifying areas where costs can be reduced or eliminated without compromising performance or security standards (Kanamori *et al*., 2019). Furthermore, it allows organisations to budget effectively, as they would be able to estimate future expenditures logically, based on current usage patterns (Watson, 2020). This maximises Return on Investment (ROI) by ensuring that all the money that would

have been spent on cloud services is channelled towards delivering tangible value to the organisation (ibid).

2.6.5 Skillset assessment

Skillset assessment is critical in ensuring the progression of CM projects by evaluating whether individuals possess the necessary competencies that are required for a seamless transition to the cloud environment (Wakefield *et al*., 2024). Assessing existing skills is crucial, as it helps organisations to understand the gaps that need to be addressed through training or hiring initiatives, before initiating the migration process. It also enables teams to leverage their strengths effectively during the implementation process. Several key skills are essential for successful CM across technical, operational, and managerial domains (Ozyurt et al., 2022). Technical skills such as mastering platforms like AWS, Azure, or Google Cloud, having a clear knowledge of network protocols, including security measures are crucial for implementing and managing resources effectively in a distributed environment (Armour et al., 2020). Operational skills encompass automation expertise using tools like Terraform for provisioning infrastructure programmatically. Additionally, managerial skills like project management abilities and effective communication are vital for overseeing complex CM projects (Alyas *et al*., 2023).

Organisations can utilise various methods and tools to conduct skillset assessments, including self-assessment questionnaires, technical interviews, and practical exercises that simulate real-world scenarios that are relevant to cloud environments (Alharbi at al., 2022). Best practices involve aligning skill assessments with organisational goals, leveraging peer feedback, and providing opportunities for continuous learning (Saiyad et al., 2020). The challenges that are commonly faced during skill set assessment processes include: resistance from employees towards evaluation; inaccurate self-assessment, which leads to biased results; and difficulties in quantifying soft skills (Rahman, 2019). To overcome these challenges effectively, organisations should foster a culture that values professional development, provides constructive feedback, and offers tailored training programmes that are based on assessment outcomes (Sousa & Rocha, 2019).

2.7 Core-requisite of CM

CM is a complex undertaking that involves various considerations such as selecting the right deployment model (public, private or hybrid), identifying suitable service models (IaaS, PaaS, or SaaS), assessing security requirements, and ensuring regulatory compliance (Shuaib *et al*., 2019). CM strategies include: re-hosting (lift-and-shift), refactoring (re-architecting), re-platforming (revising), repurchasing (replacing) and retaining/retiring applications based on specific business needs (Soewito *et al*., 2022). Successful CM requires careful planning and execution, with core requisites playing a crucial role in ensuring a smooth transition (Shuaib *et al*., 2019).

2.7.1 Assessment and planning

The assessment phase in CM involves evaluating existing IT assets, identifying dependencies between different systems or applications, assessing security requirements, analysing performance metrics, and understanding compliance needs (Fahmideh, 2019). Conducting a comprehensive assessment enables organisations to gain insights into their current infrastructure setup and determine the possibility of migrating specific workloads to the cloud (Tarride, 2022). It also helps in setting realistic goals for the migration project, estimating costs accurately, mitigating potential risks proactively, and aligning business objectives with technical capabilities.

The planning phase plays a critical role in defining the roadmap for executing a successful CM strategy. During this phase, organisations outline timelines for each stage of the migration process, allocate resources effectively across teams involved in the transition process, prioritise workloads based on their criticality and complexity levels, as well as establish communication channels between stakeholders to ensure smooth coordination throughout the project lifecycle (Kanamori *et al*., 2019).

Key considerations such as data transfer mechanisms, security protocols implementation plans, and compliance checkpoints must be addressed meticulously during this phase to avoid disruptions or bottlenecks later (Netinant *et al*., 2023).

2.7.2 Data migration strategy

The process of migrating data between various storage types and formats is called Data migration (Pijuan *et al*., 2019). In the context of CM, this entails moving data from on-premises systems to cloud-based infrastructure or between different cloud environments. Data migration plays a crucial role in ensuring that valuable organisational information is securely and efficiently transferred to the cloud, while maintaining accessibility and integrity. The types of data that need to be migrated during a CM process include: structured data such as databases; unstructured data like documents and multimedia files; historical archives; application configurations; and user settings (Hussein, 2021).

Numerous factors influence the design and implementation of a robust data migration strategy for cloud adoption (Skafi *et al*., 2020). These factors encompass aspects such as: the volume of data being migrated; complexity of existing IT environments; security requirements to safeguard sensitive information during transfer and storage in the cloud environment; and compliance regulations governing data handling practices that must be adhered to post-migration (Ardiansyah, 2023; Kanamori *et al*., 2019). Organisations need to address these factors proactively when formulating their data migration strategies, to mitigate potential risks and ensure successful transition (Weber-Lewerenz, 2021).

2.7.3 Security considerations

Security stands out as one of the most critical considerations when planning a CM strategy (Sethi *et al*., 2022). The inherently shared nature of cloud environments introduces new complexities and vulnerabilities that can pose significant risks to sensitive data and systems (Laaber *et al*., 2019). Threat actors are constantly evolving their tactics to exploit security loopholes in cloud infrastructures, thereby making it imperative for organisations to adopt robust security measures throughout the migration process.

Despite the compelling advantages of CM, there are some inherent security challenges that organisations must address proactively. One of the primary cybersecurity concerns is data breaches resulting from unauthorised access or cyberattacks during the migration process.

Hackers may exploit vulnerabilities in transit or target sensitive information stored in cloud databases. Notable examples of security breaches include the breaching of data that happened at Capital One in 2019, whereby cyber criminals gained unauthorised access to over 100 million records of clients stored on Amazon Web Services servers due to inappropriate firewall configurations (Jeong *et al.,* 2019). Given these risks, it is imperative for organisations to recognise security considerations as a core prerequisite for successful CM (Hussein, 2021). Neglecting security measures can have drastic negative results, such as financial penalties, damage to the organisations reputation, and compliance violations (Armour *et al*., 2020). Moreover, compromised data integrity or confidentiality can erode customer trust and undermine business continuity efforts.

2.7.4 Compliance requirements

Compliance requirements in CM encompass complying to regulatory laws, industry structured practices, and internal policies governing the protection of data, privacy preservation, security protocols (Bandari, 2022). In the South African context, specifically where data privacy laws are stringent due to the POPI Act, compliance becomes paramount for organisations that intend to migrate sensitive information to the cloud securely (Staunton *et al*., 2021). Failure to meet compliance requirements often results in severe penalties and legal consequences for non-compliant entities. In South Africa, the legal framework surrounding CM is primarily governed by POPI Act, which regulates how public and private entities should process personal information (Netinant *et al*., 2023). Additionally, the ECTA outline the provisions that relate to electronic transactions that are carried out via digital platforms, including those hosted on cloud services (Shibambu & Marutha, 2022). These laws underscore the importance of securing sensitive data during migration processes, while emphasising transparency and accountability from service providers (Apeh *et al*., 2023). Organisations must navigate these legal stipulations effectively, when moving their operations to the cloud.

2.7.5 Performance monitoring and optimization

Performance monitoring in the context of CM involves tracking key metrics that are related to system performance before, during, and after the migration process (IBM, 2023). Performance monitoring ensures that applications run smoothly without disruptions in the

new environment. Monitoring helps organisations to identify the bottlenecks that may arise during migration, thereby allowing for the implementation of proactive measures to address them promptly. By continuously monitoring performance metrics post-migration, organisations can optimise resource allocation based on actual usage patterns and demands (Alyas *et al*., 2023). Optimisation not only enhances system performance, but it also contributes to overall cost-effectiveness by eliminating unnecessary expenditure on underutilised resources (Ezeigweneme *et al*., 2024).

2.8 Metrics to determine the success of CM

Metrics are essential in evaluating the objective fulfilment of CM initiatives (Shuaib *et al*., 2019). Metrics provide quantifiable data that help organisations to assess performance levels, track cost-effectiveness, and measure overall efficiency post-migration. Without proper metrics in place, it is challenging for organisations to gauge the impact of their CM efforts accurately (Lei *et al*., 2019). Organisations adhere to key best practices throughout the migration process in ensuring that the migration objective is fulfilled (Jones *et al*., 2019). Thorough planning is essential, as it helps stakeholders to identify dependencies, establish timelines, and mitigate potential risks associated with migration. Data security measures are critical to safeguard sensitive information during transit and while stored in the cloud environment (Patil *et al*., 2020). Staff training is also imperative because it equips employees with the necessary skills to operate within the new infrastructure effectively. These best practices contribute significantly to a smooth transition by minimising disruptions and ensuring that organisational objectives are met post-migration (Netinant *et al*., 2023). By adhering to these practices, organisations can optimise their cloud operations and maximise ROI from their investments in cloud technologies.

2.8.1 CM KPIs

KPIs are reliable metrics used to assess the effectiveness of an organisation against its strategic objectives (Setiawan, 2020). From CM projects perspective, KPIs serve as crucial tools for measuring progress towards predefined goals and outcomes. By establishing relevant KPIs at the outset of a migration initiative, organisations can effectively track key milestones and assess whether the desired outcomes are being achieved (Berg, 2020). It is essential for organisations that will be embarking on CM

projects to have clearly defined objectives that are aligned with specific KPIs from the outset (Ardiansyah, 2023). Setting precise goals enables stakeholders to focus their efforts towards achieving measurable outcomes within stipulated timelines (Bandari, 2022). By linking objectives directly to relevant KPIs such as cost reduction targets or system uptime requirements, organisations can gauge progress better throughout each phase of the migration process.

To monitor progress effectively during the various stages of a CM project, organisations should implement robust strategies for tracking selected KPIs regularly (Fahmideh, Daneshgar, Rabhi & Beydoun, 2019). Tools like dashboards and platforms that analyse data depict the instant overview of performance metrics, thereby enabling timely interventions, where necessary. Additionally, techniques such as automated alerts notifications help organisations to identify potential issues proactively, that is; before they escalate and adversely impact project timelines (Laaber *et al*., 2019).

2.8.2 Downtime duration

Downtime duration refers to the period during which a system, application, or service is unavailable or offline (Lei *et al*., 2019). In the realm of IT operations, downtime is often viewed as an undesirable event that can lead to significant disruptions in business continuity and productivity. When organisations undertake CM initiatives, minimising downtime becomes a critical objective due to its potential impact on operations and customer experience (Shuaib *et al*., 2019). There are several factors that can influence downtime duration during the CM process. The most common challenges that can prolong downtime periods include: network connectivity issues, data transfer delays, and application compatibility problems (Setiawan, 2020). Poorly planned migration strategies, inadequate resource allocation, and lack of contingency measures can exacerbate these issues and result in extended periods of unavailability. Measuring downtime duration serves as a fundamental performance indicator for evaluating the success of CM projects (Lei *et al*., 2019). It provides insights into resource transition efficiency and post-migration effectiveness. By tracking downtime metrics rigorously, organisations can gauge their resilience to disruptions and identify areas for improvement in their migration strategies (Amaro *et al*., 2024).

2.9 Gaps of existing frameworks

This section discussed the identified gaps of the three existing frameworks namely: Microsoft CAF, AWS CAF, and CMAF. Even with the extensive nature of the existing three frameworks, the most common and persistent limitation is the lack of focus and integration of EA, at both the planning and implementation stages of CM. Architecture aspects such as system design alignment and structural integrity are underemphasised, resulting in frameworks that might not sufficiently assist organisations in maintaining coherent and scalable IT environments throughout the migration process. Therefore, although the existing frameworks provide guidance in specific domains of CM, there is still a significant need for a comprehensive framework that can explicitly incorporate architecture aspects, thus, ensuring that all AM initiatives are aligned with both technical and structural objectives.

2.9.1 Gaps within Microsoft CAF

While Microsoft CAF provides an approach for organisations that are venturing into the cloud realm, there are gaps that need to be addressed in order to enhance the effectiveness of the framework (Ardiansyah, 2023).

The first gap pertains to potential security vulnerabilities and gaps in governance that may arise during the adoption process (Nyachiro *et al*., 2023). Without robust security measures and stringent governance protocols in place, organisations risk exposing sensitive data to cyber threats and non-compliance issues (Quadri, 2017).

Microsoft CAF does not make adequate consideration of legacy systems integration, yet many organisations are saddled with legacy systems that are deeply ingrained in their operations (Singh, 2021).

Failure to pay adequate attention to the extent to which legacy systems will integrate with new cloud solutions can lead to compatibility issues, data silos, and inefficiencies in business processes (Ardiansyah, 2023). This gap can significantly impact cloud adoption processes negatively by causing implementation delays and increasing costs, due to the retrofitting of solutions that work with legacy systems (Gholami *et al*., 2016). Microsoft CAF falls short in catering to diverse organisational needs and requirements. The lack of customization options within CAF could hinder organisations from tailoring a cloud

adoption journey according to specific industry regulations or unique operational demands (Phadnis, 2022). A one-size-fits-all approach may not suffice for enterprises with complex infrastructures and specialised compliance mandates.

Limited focus on employee training and change management present another gap within the CAF framework (Nyachiro *et al*., 2023). Moving to the cloud often requires employees to adapt to new ways of working and utilising technology tools. Without proper training and change management strategies in place, employees may resist the transition or struggle to leverage the full capabilities of cloud solutions effectively (Quadri, 2017). If employees are not adequately trained to use new collaboration tools in the cloud, productivity and collaboration within the organisation would be hampered. Furthermore, the framework places little emphasis on data governance and security measures (Gholami *et al*., 2016).

Failure to establish robust data governance policies and implement adequate security measures when adopting cloud technologies can expose organisations to risks such as the breaching of data or non-compliance (Della Wirasti *et al*., 2023). Addressing the gaps requires a structured evaluation of risk, protocols for data encryption, controlling access to systems according to the roles of individuals, and auditing security on regular basis to protect information that is classified as sensitive in the cloud. Furthermore, scalability is a critical aspect of any organisation's growth trajectory when migrating to the cloud (Zbořil & Svatá, 2017). However, Microsoft CAF has limited considerations for addressing scalability challenges effectively. Organisations with varying growth trajectories find it challenging to scale their cloud resources optimally within the confines of CAF guidelines (Saurav & Bapu, 2020). This lack of scalability planning could hinder organisational agility and performance optimisation.

2.9.2 Gaps within AWS CAF

The gap within the AWS CAF is caused by inadequate security measures, such as data confidentiality and integrity. Security is a fundamental consideration in the implementation of any cloud deployment, as security involves protecting sensitive data and ensuring confidentiality, integrity, and availability (Wittig *et al*., 2023). To mitigate the risks that are

associated with unauthorised access or data breaches, organisations that adopt AWS need to carefully consider security controls such as the management of identity and authorisation, mechanisms of encryption, configurations for securing the network, logging, and monitoring tools (Sharma, 2020). Compliance challenges can also pose as a gap in the effective adoption of the AWS CAF. Different industries have specific regulatory requirements that govern how data should be stored, processed, and transmitted (Ucuz, 2020).

Organisations that leverage AWS services also need to abide to compliance standards such as GDPR , PoPI, PCI DSS, among others. Neglecting thorough attention to compliance challenges can lead to implications that are legally intensive and the risk of organisations' reputation. Cost management issues represent another potential gap in implementing AWS CAF efficiently (Della Wirasti *et al*., 2023). While cloud computing offers scalability benefits by allowing organisations to pay only for what they use on an on-demand basis, lack of proper cost optimisation strategies can result in overspending (Sanyal *et al*., 2017). As a result, organisations must closely monitor their resource usage patterns, leverage cost-effective pricing options like reserved instances or savings plans that optimise workloads for performance efficiency (Ardiansyah, 2023).
Integration complexity can be a significant hurdle in leveraging the full potential of the AWS CAF effectively (Nyachiro *et al*., 2023).

Many organisations operate in hybrid environments, where they need to integrate on-premises systems with cloud-based resources seamlessly (Sanyal *et al*., 2017). Managing integration complexities requires careful planning of architecture design decisions and configuration settings that prioritise interoperability scalability across different platforms, while maintaining the performance reliability levels expected by end-users, customers and other stakeholders (Zbořil & Svatá, 2017).

2.9.3 Gaps within CMAF

The gap within McKinsey's CMAF pertains to its potential oversight of comprehensive risk assessment strategies related to CM (Shaqiri, 2023). Organisations may face various risks during migration, including data breaches, regulatory compliance issues, service

interruptions, and unexpected costs (Salehi & Li, 2022). While CMAF addresses some common risks associated with CM, it does not encompass all scenarios nor adequately prioritise certain risks, based on organisational priorities (Nyachiro *et al*., 2023). For example, specific industry regulations and data privacy laws that are unique to an organisation's operations may not receive sufficient emphasis within the risk assessment component of the framework.

Data security is a paramount concern for organizations considering CM because of the sensitivity of the business records stored in the cloud environment (Della Wirasti *et al*., 2023). The gap in CMAF involves inadequate coverage of robust data security measures during the migration process. Thus, it is imperative for organisations to ensure that proper encryption protocols are in place both during transit and at rest when migrating data, to prevent unauthorised access or breaches (Zbořil & Svatá, 2017; Wittig *et al*., 2023). This factor should be more explicitly outlined within CMAF guidelines (ibid).

Scalability plays a vital role in determining how well an organisation can effectively adjust its resources according to changing demands, post-migration (Nyachiro *et al*., 2023). It allows organisations flexibility, while also ensuring optimal performance levels. Therefore, it is essential for CMAF scalability planning components to consider both short-term spikes in demand, as well as long-term growth strategies. Without adequate focus on scalability planning, organisations risk facing operational constraints and inefficiencies after migrating their services to accommodate future business needs optimally (Quadri, 2017; Salehi & Li, 2022).

2.10 Identification of required design criteria from the literature

The literature reveals lack of coordinated process models for migration and comprehensive architectural approaches for CM applications modernisation. Cardoso *et al*. (2014) discuss CM issues in existing models and conclude that, although there are frameworks for CM, none of them describes the methods for enforcing the actions that are needed for completing the associated process. There is a gap in the link between architecture and CM, as none of the frameworks ties the latter as a form of AM to the former. It is also apparent that the field of AM architecture is under-researched. The

design criteria, which have been established for the artefact to resolve the issue, include strategic alignment and planning, and alignment with EA. They also place emphasis on AM and integration across concepts. In Chapter 4, the identified design criteria will be used to develop the proposed framework.

2.11 Conclusion

Given the above literature, there is a need to synthesise the literature, because it is fraught with gaps. Chapter 3 discussed the DSR methodology. The design criteria that were identified in the literature and the DSR methodology were used to develop a proposed research artefact/framework in Chapter 4, based on the synthesis of the knowledge acquired during the review of the literature presented in the current chapter. In Chapter 5, the proposed framework was evaluated by a panel of experts. Finally, Chapter 6 presented the research conclusion and recommendations.

3 Research methodology

3.1 Introduction

The focus of this Chapter is the discussion of design science research (DSR) methodology, which was used to develop the proposed framework. DSR is regarded as a collective approach for developing artefacts to address problems (Vaishnavi *et al*., 2011). The discussion of the research strategy positioned the DSR approach and its use in this research. Further, the discussion clearly illustrated the stages of the DSR methodology. The map of the Chapter was illustrated in Figure 10.

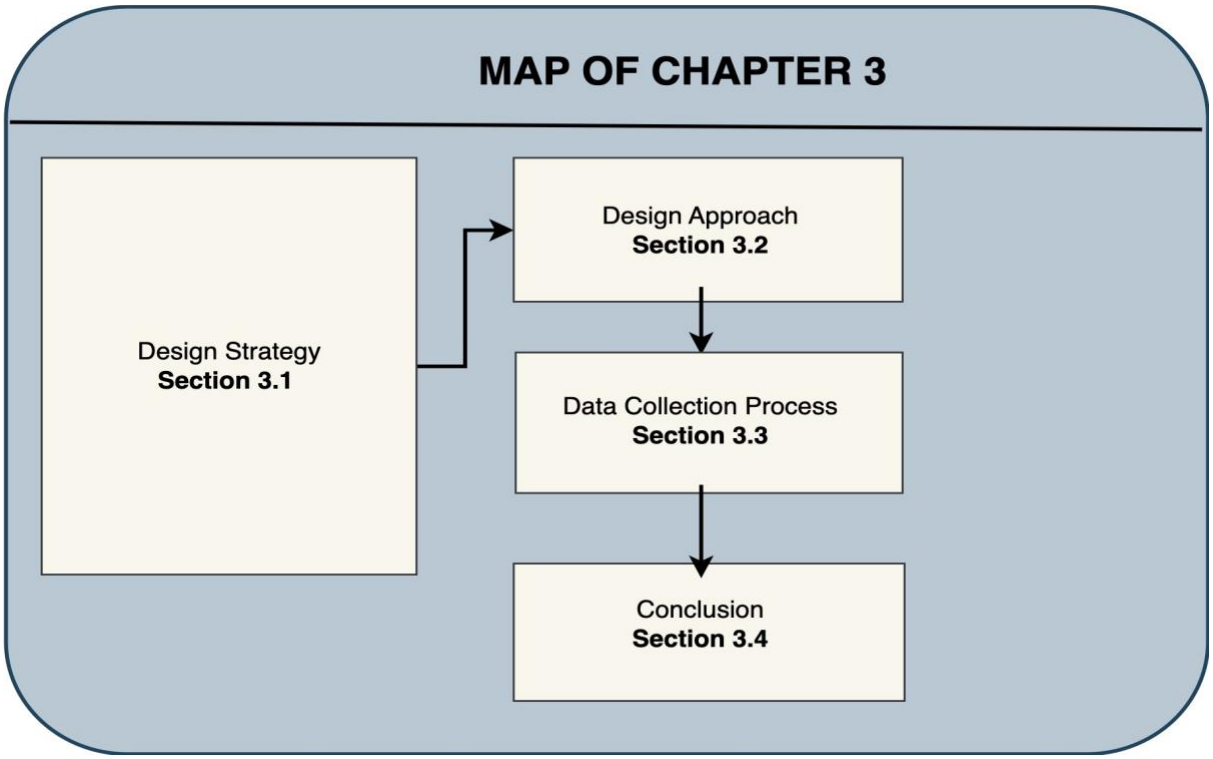

Figure 10 Map of Chapter 3

3.2 Research strategy

The aim of DSR is to resolve problems by constructing a new reality instead of stipulating and clarifying the existing one (Kuechler *et al*., 2012). DSR offers a systematic and rigorous methodology for creating and evaluating artefacts that address identified organisational challenges while generating both practical value and theoretical contributions (Hevner et al., 2004). Consequently, this study adopted the DSR

methodology to develop and evaluate an EA-driven framework to support AM. The continued evolution and application of DSR is evidenced by more recent work that further refines DSR principles and practices within contemporary research environments (Hevner & vom Brocke, 2023). The DSR process solves problems by using experience from gained knowledge, thereby enhancing existing solutions and bringing change (Wieringa, 2010). DSR creates awareness and innovative knowledge by including the creative design between experimented and affirmative research actions, after which the design solution is then tested and validated (ibid).The primary method of achieving the aim of this research entailed analysing past studies on the status quo of the existing migration frameworks, the linked concept of EA, CM and AM.

The DSR process involves the design of artefacts to resolve problems, assess what has been designed or what is working, after which it presents and communicates the solution (Kuechler *et al*., 2011). The key feature of DSR is its capability to resolve identified organisational problems through the design and evaluation of artefacts that provide suitable effective solutions. (Peffers *et al*., 2007). Figure 11 illustrates the cycle of DSR.

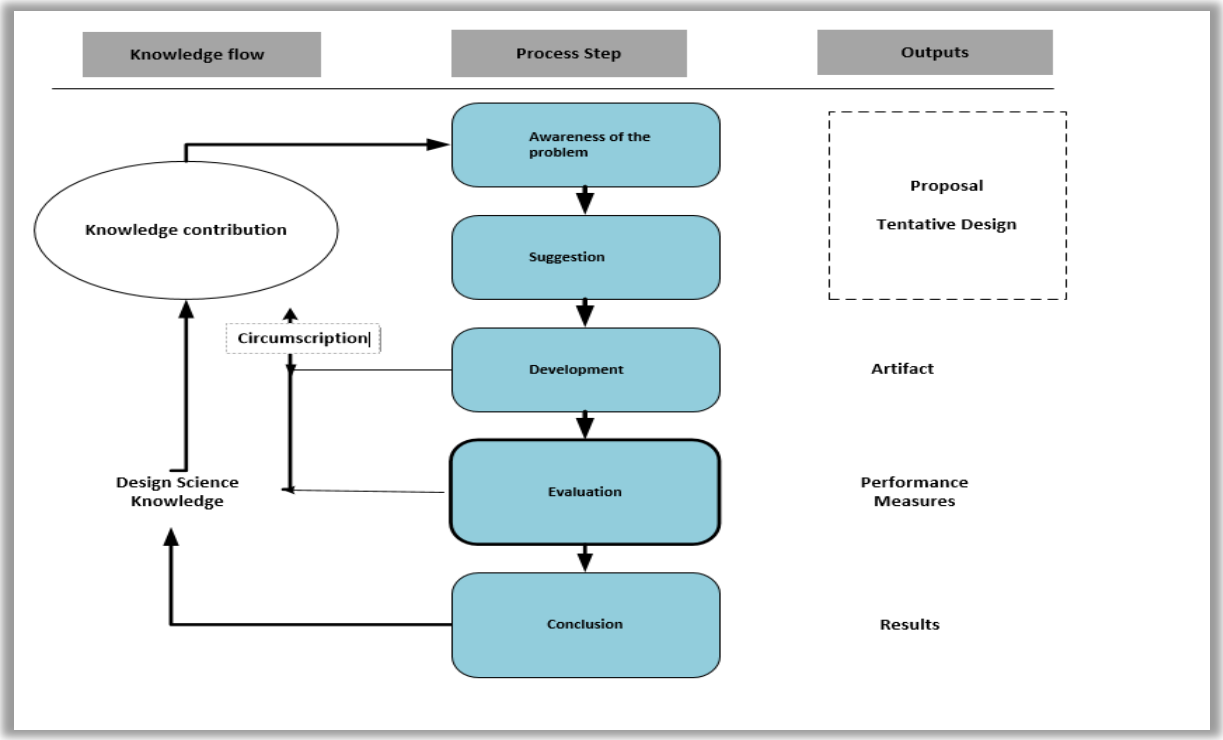

Figure 11 Workflow Model of DSR (Vaishnavi et al., 2011).

The first stage of the DSR approach entails the defining and understanding the problem. At this stage, the problem is known from the relevant literature, and the value of the proposed solution is then motivated. The second stage is the proposal of criteria to design the solution for solving the identified problem. The use of prior knowledge and creativity is significant at this stage (Vaishnavi *et al.*, 2012). The first and second stages of DRS are presented in Chapter 2, section 2.9. The third stage, which was comprehensively presented in Chapter 4 of this study, is the design and creation of the framework as a solution to the identified problem. In this research, the ACMF was proposed. The fourth stage is the evaluation of the designed research artefact, where it is demonstrated to selected audiences, who then provide recommendations (Vaishnavi *et al.*, 2012). The fourth stage of DSR approach was illustrated in Chapter 5, where the proposed framework was evaluated by a panel of experts.

3.3 Research approach

The objective of the DSR approach is to solve problems by constructing a new reality, instead of stipulating and clarifying the existing one (Vaishnavi *et al*., 2011). This research focused on the five main stages of the DSR approach model, as defined by Kuechler *et al*., 2012. The stages outlined below depict how the DSR approach was applied in the development of the framework in Chapter 4.

Stage 1: Awareness of problem

The lack of a standard approach to migrate in-house IT systems to cloud, in the context of AM was identified as a fundamental problem. The analysis and review of existing literature guided the identification and definition of the problem and its relevance to the organisational and academic community. Organisations are migrating IT systems to the cloud, however, the stage to stage facilitation approach to enable the migration architecturally is not outlined.

Stage 2: Proposed solution

The proposed solution to address the problem is the development of the architectural framework for facilitating the transitioning of existing applications to the cloud in the context of AM. The proposed solution is attained through the support of existing theoretical and empirical knowledge. The comprehensive review of literature in Chapter

2 illustrated the need to synthesise the literature, because it has some gaps. Labes *et al*. (2012) mention that organisations migrate IT systems to cloud using any approach that best suits their requirements, which means that there is no standardised approach.The gap in the academic community regarding the limited knowledge of approaches for facilitating CM architecturally needs to be addressed.

Stage 3: Development

The design and development of the research artefact as a solution to address the identified problem is conducted in the third stage of DSR approach. This research developed the proposed ACMF framework, whose design was illustrated in Chapter 4.

Stage 4: Evaluation

The fourth stage assessed the proposed designed framework to ensure that it was appropriate for the proposed use and it satisfied the criteria for its development (Vaishnavi & Kuechler, 2011).The evaluation was conducted by demonstrating and presenting the framework to a panel of experts, including technology and management-oriented participants. The evaluation data were analysed qualitatively using data analytic tools, and the findings were used to improve the proposed framework. The recommendations and refinements from the experts was used for the enhancement of the framework. The DRS approach cycle ends when the designed artefact adheres to the design criteria and requirements of the identified problem (Vaishnavi & Kuechler, 2019).

3.4 Data collection

The framework was evaluated by industry experts with experience in EA, CM, and technology transformation. Prior to the evaluation an interactive workshop was conducted with participants through Microsoft teams ,where the arch CM framework was presented and discussed before completing the evaluation questionnaire. The entire session was recorded, and the recording was stored in a central repository for future reference. This provided participants with sufficient opportunity to familiarise themselves with the framework and seek clarification on any aspects requiring further explanation. Following the workshop, the framework documentation and structured evaluation questionnaires were distributed through email to experts from various organisations, enabling participants to undertake a considered evaluation of the framework following independent

review. All unbiased input, feedback, and recommendations from the experts were analysed qualitatively. Figure 12 illustrates the process flow of how data were collected.

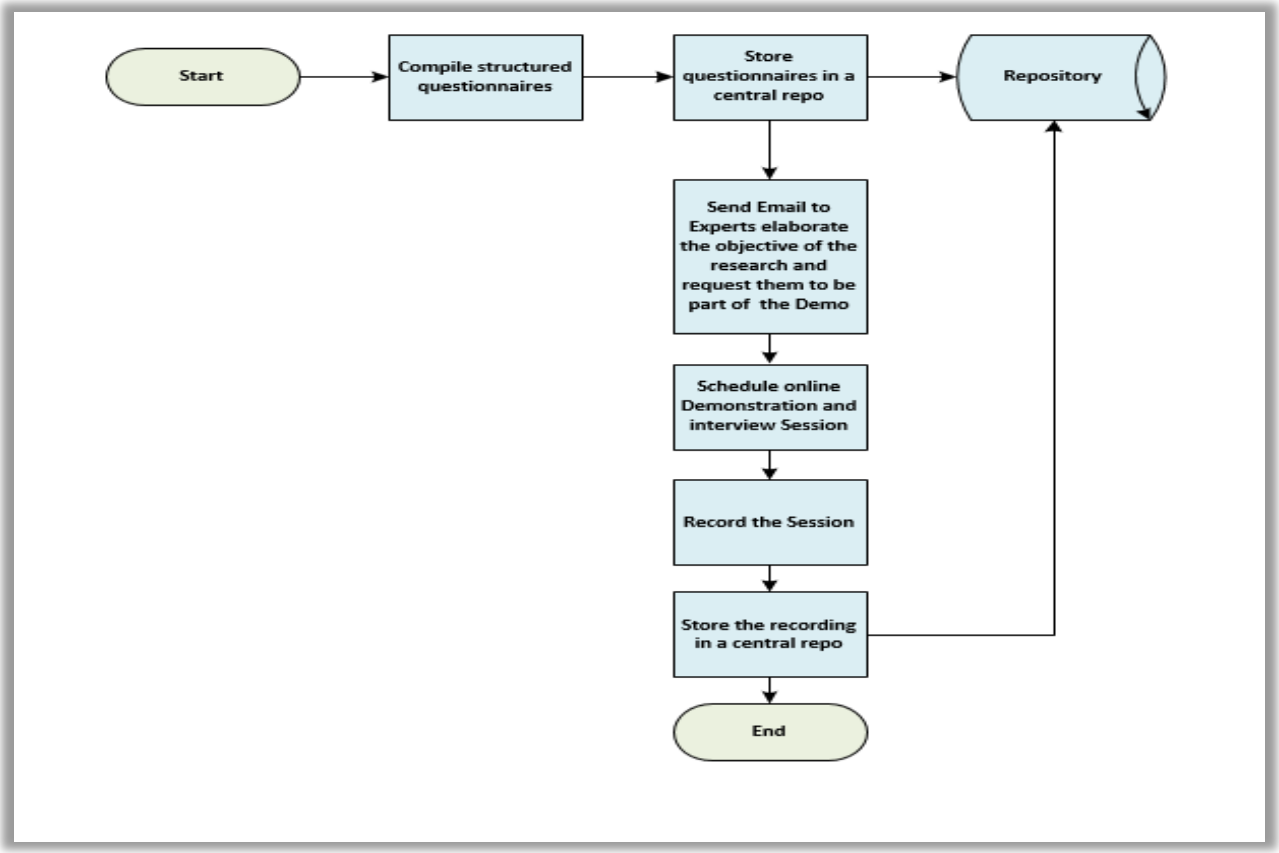

Figure 12 Evaluation of the data collection process (collated by researcher)

3.5Discussion of questionnaires

The data for this study were collected through a structured questionnaire that was designed to assess the relevance and effectiveness of the proposed framework for facilitating CM. The framework comprises five phases, which are: strategic alignment and planning, alignment with EA, emphasis on AM, integration across concepts, and continuous improvement. Each phase of the framework was addressed through a set of targeted questions that were aimed at gathering insights from the industry experts, enterprise architects, and professionals who were involved in CM projects.

The questionnaire was divided into five sections, each corresponding to one of the phases in the proposed framework. The questions were designed to gather participants' opinions on the importance, challenges, and best practices that were associated with each phase.

3.5.1 Strategic alignment and planning questionnaires

The questionnaire required the participants to examine the clarity, comprehensiveness and areas for improvement or extension of each section, regarding the strategic alignment within the framework. The participants were also asked to evaluate the perceived effectiveness of the strategic alignment phase of the proposed framework and indicate whether the essential features of that phase were adequately addressed. In addition, an open-ended response option was provided to enable the participants to identify any of the features that they believed were missing from the strategic alignment phase. The following set of questions originated from the strategic alignment and planning phase of the proposed framework. Each question was elaborated in detail in the subsections below.

3.5.1.1 How effectively and sufficiently does this section outline key strategic alignment components?

The aim of this question was to assess whether the section of the framework dedicated to strategic alignment clearly and comprehensively covered all the essential components that were needed to align the framework with the organisation’s overall strategy.

3.5.1.2 Does this section sufficiently outline strategic alignment features?

This question evaluated whether the framework adequately described and covered the features of strategic alignment such as setting goals, measuring success, or adapting to changes in the business environment.

3.5.1.3 What additional features do you recommend being included in this section?

This question sought feedback pertaining to any missing or underdeveloped areas in the current description of strategic alignment. The respondents were required to suggest any enhancements that could improve the alignment of the framework with the organisation's strategic goals. The aim of the open-ended question was to gather recommendations for improvement, as well as identify any gaps in the current strategic alignment features of the framework or any additional components that could make it more effective.

3.5.2 Alignment with EA questionnaires

This phase is crucial because EA (EA) serves as the blueprint for an organisation's IT infrastructure, including its strategy, systems, technologies, and processes. The goal of CM in the context of EA is to ensure that the transition to the cloud complements and enhances the existing architecture, rather than causing fragmentation or misalignment. Below, the three key questionnaires and their purposes are further broken down.

The main goal of this phase is to assess how well the proposed framework fits into the larger context of the EA. A strong alignment ensures that the framework will support the organisation's long-term strategy and enterprise-wide goals, which is essential for sustainability. The focus of the questions was to examine the degree to which CM supported existing IT infrastructure and EA principles. Each of the questions addressed the crucial aspects of the alignment between the CM strategy and EA principles. Ensuring alignment with EA helps to avoid integration issues, manage risk, and optimise resources. Experts can recommend the inclusion of a method for ongoing feedback to ensure that the CM remains aligned with evolving strategic priorities over time.

3.5.3 Emphasise on AM questionnaires

This question was designed to evaluate whether the CM framework adequately emphasised the critical elements of AM and provided a clear plan for transforming legacy applications into cloud-optimised solutions. AM involves rethinking and redesigning the applications to leverage the full potential of cloud environments. Thus, the question assessed whether the framework adequately covered these modernisation strategies and considered all the modernisation aspects.

3.5.4 Integration across concepts questions

The integration across concepts phase is a critical milestone in the CM framework, because it ensures that various key concepts (such as platforms, technologies, processes, and business functions) work together cohesively during and after the migration. The purpose of this category of questions was to evaluate whether the CM framework adequately emphasised and facilitated the integration of multiple key concepts that were necessary for a successful CM.

3.5.5 Continuous improvement questions

The goal of the continuous improvement phase is to ensure that CM is an ongoing process not a once-off event. Once the migration has taken place, the focus shifts to continuous optimisation and refinement of the cloud environment to maximise efficiency, performance, and business value. The questions evaluated how well the proposed framework integrated mechanisms for gathering feedback during and after the migration process.

The feedback mechanism is crucial because it helps the organisation measure the success of the migration, identify areas for improvement, and adapt the cloud environment to meet business goals more effectively. The questions required the experts to propose additional features or mechanisms that should be considered for the continuous improvement phase. While the section might have already outlined the basics, this question aimed to uncover any gaps or suggest new methods, tools, or strategies that could further enhance the long-term success of CM.

3.6 Ethical considerations

This study met all ethical requirements, and the approval was granted by the IRB of the university. The purpose of the study was outlined for all participants to have an informed understanding, and they were provided with a descriptive consent form that guaranteed their anonymity and confidentiality. Additionally, the collected data was securely stored and could be accessed by the research team only, thereby ensuring adherence to the requirements of data protection.

3.7 Conclusion

The questionnaire served as a critical tool for validating the effectiveness of the proposed framework for CM. It provided critical insights into the strengths and weaknesses of each phase of the framework, thus, helping to highlight the areas that needed further refinement. The findings of the study indicated requirements of successful CM, with respect to strategic planning and continuous refinement, thereby ensuring that the framework would remain adaptable to evolving organisational needs.

4. The development of the proposed framework

4.1 Introduction

This Chapter aimed to develop a proposed framework supported by EA to facilitate CM in driving AM. The Chapter illustrated the design criteria for the proposed framework (as gleaned from the literature in Chapter 2). The structure of this Chapter is illustrated in Figure 13.

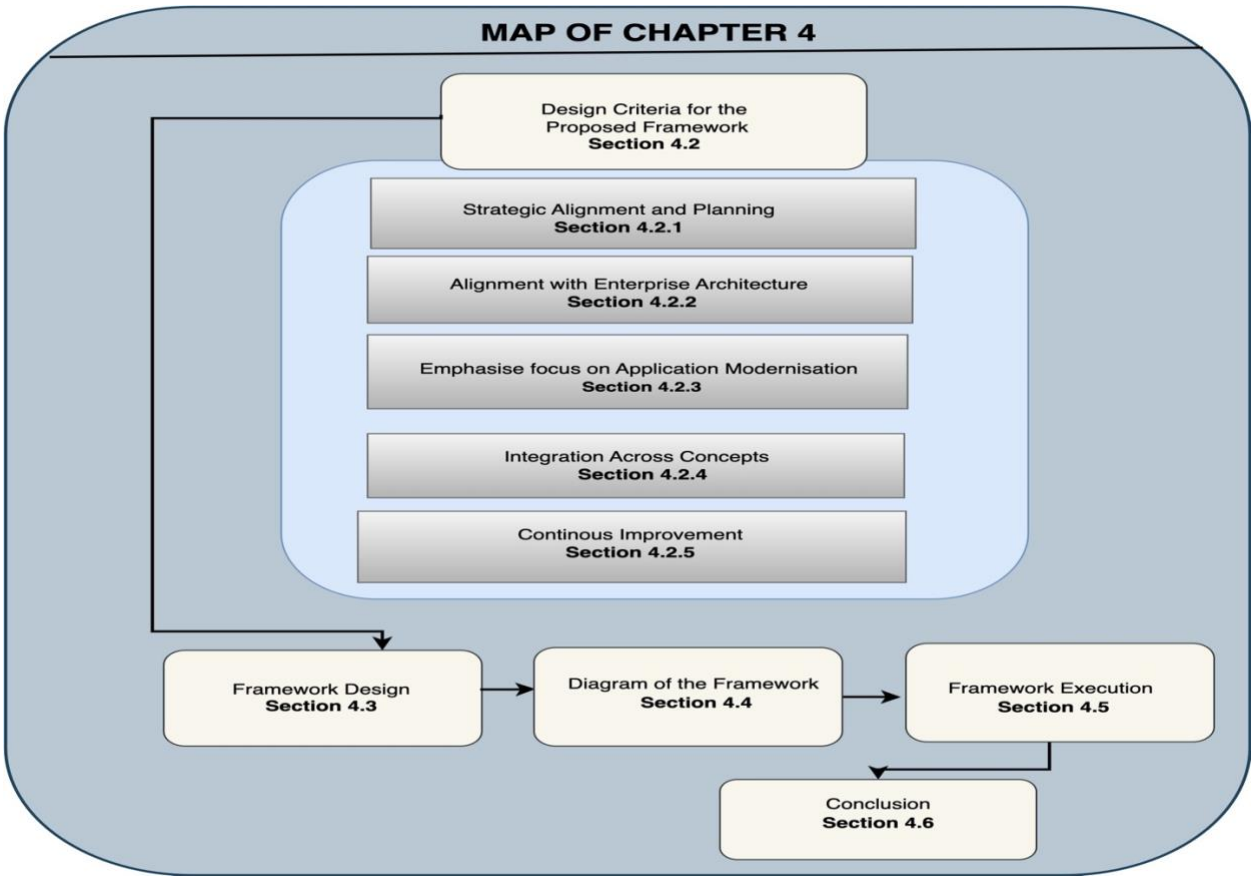

Figure 13 Map of Chapter 4

4.2 Design criteria for the proposed framework

Before designing a comprehensive CM framework, it is crucial for organisations to conduct different phases, as outlined below. The design criteria formulated for the proposed framework originates from the comprehensive synthesis of existing CM literature by both academics and practitioners. These criteria were intentionally selected to address the gaps that were identified in the existing migration frameworks, with specific regard to insufficient focus on architectural aspects.

4.2.1 Phase 1: Strategic alignment and planning

The following steps are conducted during the strategic alignment and planning phase of the framework.

Step 1. Define business objectives and goals

It is critical to align CM goals with the broader business strategy and identify how it supports business growth, innovation, and competitive advantage. It is imperative to set clear, specific and measurable migration goals, which entails the establishment of cost saving measures, improved scalability and enhanced agility. Cost efficiency plays a pivotal role in the success of any CM endeavour for architecture enterprises (Phadnis, 2022). As organisations aim to optimise organisational IT spend and maximise ROI, it becomes imperative to streamline costs during the migration process.

A well-defined cost efficiency strategy can help businesses to allocate resources judiciously, avoid unnecessary expenses, and ensure long-term sustainability in the cloud environment (Nyachiro *et al*., 2023). To achieve optimal results, it is essential to customise the CM framework to the specific requirements of architecture enterprises. Such customisation may involve integrating industry-specific tools or compliance measures into the framework, aligning with existing IT infrastructure seamlessly, and considering regulatory constraints that govern architectural practices (ibid).

Step 2. Develop a cloud strategy

The cloud model is supported by the service model; therefore, it is critical to selecting models such as IaaS, PaaS, SaaS or a combination thereof, depending on the application needs and business requirements (Ardiansyah, 2023). During the strategic alignment and planning phase, it is important to define clear migration approaches and strategies and tailor them to different application types and business requirements.

Step 3. Develop cost efficiency and optimisation strategy.

As organisations aim to optimise the IT expenditure and maximise ROI, it is imperative to streamline costs during the migration process, because cost efficiency plays a pivotal role in the success of any CM (Phadnis, 2022). A well-defined cost efficiency strategy can help organisations to allocate resources judiciously, thereby avoiding unnecessary

expenses (Nyachiro *et al*., 2023). In this case, organisations can obtain optimal results by customising the CM framework to their own unique needs (ibid). This entails seamlessly aligning industry-specific tools with existing IT infrastructure and taking heed of the regulatory constraints that govern architectural practices (ibid).

4.2.2 Phase 2: Alignment with EA (EA)

During the EA alignment phase, it is critical for the organisation to ensure that the CM supports its long-term business strategy and IT roadmap. The migration framework should align with the EA, which helps to ensure that all systems and processes across the organisation are integrated and optimised (Ardiansyah, 2023). It is imperative to create a comprehensive inventory of existing applications, database and infrastructure, while ensuring that the architecture review is conducted to evaluate the current architecture against capabilities and identify gaps (ibid).

The following steps are conducted during the strategic alignment and planning phase of the framework.

Step 1. Assess current architecture

During this step**,** the existing IT infrastructure applications, and data systems are reviewed. This helps the organisation to understand its current state and readiness for the cloud. In the process, the architectural gaps and dependencies that need to be addressed are also identified.

Step 2. Develop target architecture

Designing a cloud architecture blueprint that aligns with business goals and addresses current gaps ensures the incorporation of scalable, secure, and resilient design principles that are suitable for the cloud.

Step 3. Governance, security and compliance

The framework incorporates enterprise-wide governance policies, thus, ensuring that the migration process adheres to regulatory requirements, data protection laws, and industry standards. Designing a secure CM framework requires meticulous planning and execution, while prioritising data protection and privacy is central to the design principles

that apply to the principle (Gholami *et al*., 2016). Conducting thorough risk assessments to identify vulnerabilities and defining clear security controls are some of the fundamental steps that fortify the overall security posture (Singh, 2021).

The encryption of at rest and in transit data ensures confidentiality, while the implementation of disaster recovery mechanisms enhances resilience against unforeseen incidents (Ardiansyah, 2023). In addition, the task of ensuring compliance throughout the CM lifecycle demands proactive measures from architecture enterprises. In the same vein, it is essential to establish governance structures that oversee compliance adherence across all the stages of migration (Ucuz, 2020). Collaboration with legal experts can provide insights into the evolving regulatory landscape, thereby enabling enterprises to stay ahead of the compliance requirements.

Step 4. Scalability and flexibility

The proposed ACMF framework accommodates future growth and changes in the business environment. This ensures that the cloud architecture can evolve without disrupting the EA of the organisation.

Step 5. Performance and availability

Ensuring that the cloud architecture meets the performance and availability requirements of the business. The performance and availability stage includes activities such as defining service level agreements (SLAs) and implementing redundancy, load balancing, and disaster recovery solutions (Ardiansyah, 2023). For the proposed framework, scalability is critical in accommodating fluctuating demands on resources, while maintaining optimal user experience levels. By designing a scalable CM framework, organisations will be able to future-proof infrastructure against sudden spikes in traffic and data volumes, which may occur as they expand the current operations.

4.2.3 Phase 3: Emphasise focus on AM

Below are the stages conducted during phase 3.

Step 1. Assessment and prioritisation

It is imperative to evaluate existing applications to determine the suitability for CM, because not every application is a candidate for CM. Applications should be prioritised based on factors such as business value, complexity, and the level of effort required for modernisation.

Step 2. Re-factoring and re-platforming

During the refactoring and re-platforming stage, the modernisation approach for each application - be it re-factoring to optimise for cloud-native features, re-platforming to a more cloud-friendly environment, or even retiring and replacing outdated applications – should be considered.

Step 3. Automation and DevOps

The incorporation of development operations practices and automation tools helps to streamline application deployment, scaling, and monitoring in the cloud environment, thereby facilitating continuous improvement and reducing downtime.

Step 4. Performance monitoring and optimisation

Performance monitoring in CM refers to the ongoing process of tracking and analysing system performance metrics before, during, and after the migration process (Nyachiro *et al*., 2023). Monitoring and optimisation help organisations to identify bottlenecks, optimise resource utilisation, detect potential issues early on, and ensure that performance targets are met post-migration (ibid). Effective performance monitoring is essential for making informed decisions regarding resource allocation (Ardiansyah, 2023). Optimisation strategies is a very essential aspect because it enhances the performance of applications during CMs. Various optimisation techniques such as workload balancing and caching mechanisms can be implemented within a CM framework to improve efficiency, reduce costs, and optimise resource utilisation (Salehi & Li, 2022). While optimisation strategies offer significant benefits, organisations may also face challenges such as compatibility issues, data transfer bottlenecks, and potential security vulnerabilities during implementation.

Step 5. Resilience and disaster recovery

In the context of CM resilience is paramount, as organisations transition critical workloads and data to cloud environments. Resilience involves designing systems that can adapt to changing conditions, recover from failures, and continue operating seamlessly despite disruptions (Ardiansyah, 2023). Some of the key factors that contribute to resilience in a cloud environment include: redundancies in data storage and network connectivity; automated failover mechanisms; robust security measures; real-time monitoring; and alerting systems; as well as comprehensive backup strategies (Gholami *et al*., 2016).

Disaster recovery planning is essential for organisations that will be embarking on CM projects to mitigate the risks associated with potential disruptions such as cyber-attacks, natural disasters, or hardware failures (Della Wirasti *et al*., 2023). The process of disaster recovery involves the following: identifying critical assets and services; assessing potential threats and vulnerabilities; implementing backup solutions (on-premises or offsite); conducting regular testing drills; and documenting procedures for swift response and recovery (ibid).

Step 6. Flexibility and hybrid capabilities

Flexibility is a cornerstone element in any successful CM framework. The dynamic nature of business requirements necessitates the adoption of adaptable solutions that can accommodate changes swiftly (Sharma, 2020). A flexible framework enables organisations to respond promptly to shifting demands and technological advancements without compromising operational efficiency or scalability (Gholami *et al*., 2016).

By embracing flexibility within the migration strategy, organisations can future-proof the architectures and ensure sustained relevance in the ever-evolving digital landscape.

Hybrid capabilities refer to the integration between on-premises infrastructure and multiple public clouds within a cohesive ecosystem (Sharma, 2020). The hybrid approach combines the advantages of both private and public clouds, while offering greater flexibility and resilience against potential downtime or data loss scenarios. For organisations that adopt a multi-cloud strategy, having hybrid capabilities becomes instrumental in optimising resource utilisation effectively across diverse environments (Sharma, 2020).

4.2.4 Phase 4: Integration across concepts

Integration across concepts involves designing the migration framework to have a holistic view of EA, AM, and CM as interlinked processes, rather than as separate initiatives. The objective of the integration across concept is to achieve a seamless integration of cloud systems and ensuring the consistency and operational efficiency across all platforms (Fahmideh *et al*., 2020). The steps below are conducted during the integration across concepts phase.

Step 1. Iterative and agile approach

The iterative approach to CM allows for continuous feedback and adjustment, so it is prudent for organisations to adopt it. The approach also ensures that the framework remains agile and responsive to changes in business needs and technology advancements.

Step 2. Measurement and KPIs

The CM team must define KPIs that determine the effectiveness of the CM against EA goals and AM outcomes. The goals and outcomes must be reviewed regularly and all the framework outcomes that are based on these metrics must be adjusted. Collaboration plays a critical role in the success of any CM initiative. In the context of architecture enterprises, effective collaboration among team members, departments, and stakeholders is vital for aligning business goals with technical requirements during the migration process (Della Wirasti *et al*., 2023). By fostering open communication channels and promoting knowledge sharing among diverse groups within the organisation, collaboration can help to mitigate risks, resolve conflicts proactively, and ensure that all stakeholders are working towards common objectives (Quadri, 2017).

Workflow integration is another key aspect that contributes to the efficiency and effectiveness of a CM framework. By integrating workflows seamlessly into the migration process, organisations can automate routine tasks, standardise procedures across different teams, and improve overall operational efficiency (Zbořil & Svatá, 2017). Workflow integration also enables better visibility into project timelines, dependencies

between tasks, and resource allocation management, all of which are essential for meeting project deadlines successfully.

Step 3. Training and support

Given that training and support for the CM team is very crucial, the organisation should conduct a thorough training needs assessment to identify gaps in employees' skill sets or knowledge levels related to implementing the CM framework effectively (Gholami, *et al*., 2016). Conducting a training needs assessment helps organisations to determine which areas require additional training or upskilling initiatives, before embarking on the actual migration journey. To determine internal skill gaps, organisations should conduct surveys and interviews with stakeholders, wherein they review job descriptions and analyse employee performance (Phadnis, 2022).

The CM team must design effective training programmes that are tailored specifically towards the organisation's needs and different learning styles (Nyachiro *et al*., 2023). This entails using various training formats such as workshops, seminars, online courses, hands-on laboratory simulations, virtual classrooms, and blended learning approaches (ibid). Moreover, the CM team must identify subject matter experts and task them with developing relevant training material that can leverage reputable external training partners (Salehi & Li, 2022).

4.2.5 Phase 5: Continuous improvement

Continuous improvement is essential for ensuring that the proposed Arch CM Framework remains relevant and effective in addressing the evolving challenges and opportunities in CM. By continuously refining processes, updating best practices, and incorporating lessons learned from previous migrations, organisations can enhance the overall efficiency, reduce costs, and mitigate risks associated with cloud adoption.

To implement continuous improvement effectively within the proposed Arch CM Framework, organisations can leverage various strategies such as conducting regular assessments to identify areas for enhancement, establishing feedback loops with stakeholders who are involved in migration projects, and implementing performance

monitoring mechanisms to track key metrics related to migration success rates and outcomes.

Step 1. Innovation and adaption

During this step organisations should ensure that cloud environment evolves even post migration. New cloud capabilities and opportunities should be adopted to solve changing business needs. Lesson learned from the previous migrations should be leveraged to enhance governance processes.

Step 2. Continuous refinement

Continuous refinement is critical, therefore, the CM team should conduct the iteration on the cloud architecture and processes, based on feedback and changing business needs.

Step 3. Feedback and iteration

The CM team should collect feedback from stakeholders and end-users through various methods such as surveys. The iterative process of modernisation requires regular reviews of the EA, technology landscape, and business requirements. As organisational needs evolve, additional enhancements, refinements, or architectural adjustments may be required. Feedback from each iteration informs subsequent improvements, ensuring that the solution remains aligned to business objectives and technological advancements.

4.3 Framework design

Framework name: ACMF

The proposed ACMF provides a structured approach to migrating IT systems and applications to the cloud, while minimising risks and disruptions. At its core, the proposed ACMF comprises several key components that are aimed at guiding organisations through every phase of the migration journey. These components include 4.2.1 Phase 1: Strategic alignment and planning, 4.2.2 Phase 2: Alignment with EA (EA) , 4.2.3 Phase 3: Emphasise focus on AM, 4.2.4 Phase 4: Integration across concepts, and 4.2.5 Phase 5: Continuous improvement. Before embarking on a CM project using the ACMF or any other similar methodology, it is crucial for the CM team to plan and align the strategy. The planning phase plays a vital role in laying down the foundation for successful CM projects (Sanyal, et al.,2017). During the planning phase, organisations define the objectives, set

measurable goals, allocate necessary resources, establish timelines, and create contingency plans in case of unforeseen circumstances (Zbořil & Svatá, 2017).

Effective planning ensures that stakeholders are aligned, expectations are managed, risks are mitigated, and budgets are optimised throughout the CM project. Engaging stakeholders across different departments, including IT teams, business units, security professionals, compliance officers, and finance personnel ensures that diverse perspectives are considered when making critical decisions regarding cloud adoption. Stakeholders bring domain-specific knowledge that can inform strategic choices related to workload prioritisation and risk management strategies. A comprehensive assessment strategy is essential for ensuring successful CM within ACMF.

During the planning and strategy alignment phase, the business case development serves as a foundational step in decision-making processes within organisations (Zbořil & Svatá, 2017). Alignment entails a structured approach to evaluating the potential costs and benefits of implementing a particular initiative or project. The proposed ACMF enables each organisation to adopt a structured approach towards planning and executing CM strategies. By leveraging the proposed ACMF framework, businesses can streamline the migration process, while ensuring alignment with organisational goals and objectives. Once initial planning is complete, organisations can move on to aligning the CM journey with the EA, to understand the current system that needs to be migrated. The alignment involves conducting a comprehensive assessment of existing infrastructure applications, data workloads, security protocols and compliance requirements (Quadri, 2017). By gaining insights into alignment aspects, organisations can identify potential challenges and opportunities for improvement and, consequently, develop a clear roadmap for migration.

Evaluating the state of the existing infrastructure is a critical component of EA alignment which entails evaluating the current hardware, software systems, network architecture, security protocols, including data storage solutions to determine compatibility with cloud environments (Gholami *et al*., 2016). Understanding the elements of the current infrastructure that need to be modernised will help the CM team to develop an effective

migration strategy. Assessing each application and categorising workloads according to complexity and criticality levels helps organisations to prioritise which application should be migrated first or require further optimisation before CM (ibid).

Risk assessment is also an essential aspect in ensuring the effectiveness of CM projects. Therefore, conducting a thorough evaluation of potential risks such as security vulnerabilities, compliance issues, data loss, and downtime helps organisations to take proactive action in identifying areas that may pose challenges during migration (Nyachiro *et al.*, 2023). Organisations should minimise security risks by implementing mitigation strategies such as data encryption, data backup, and redundancy measures (ibid).When designing an effective framework for CM such as the proposed ACMF, key factors such as scalability, security, flexibility and interoperability must be considered. Scalability is essential for accommodating varying workloads, while ensuring optimal performance and resource allocation (Sharma, 2020). Security measures are critical for safeguarding sensitive data throughout the migration process, and after deployment in the cloud environment.

Flexibility enables seamless integration with existing systems, while allowing for future updates and modifications without disrupting operations. Interoperability ensures smooth communication between different components within the framework and with external systems or services (ibid).It is critical for CM teams to emphasise focus on AM, because this phase allows organisations to assess the feasibility of the migration strategy, identify potential challenges early on, and make the necessary adjustments before committing resources to a large-scale deployment (Salehi & Li, 2022). Conducting a pilot migration is essential for minimising the risks associated with CMs and ensuring a smooth transition process (Gholami *et al*., 2016). In terms of using the application migration approach during the pilot phase of the proposed Arch CM Framework; it is crucial to select suitable applications on the basis of predefined criteria, as this ensures that the desired outcomes are achieved with relative ease (ibid).

4.4 Diagram of the framework

The design of the proposed ACMF completes step 3 of the DSR methodology that was adhered to in this research. Figure 14 depicts the high-level view of the proposed framework, whose finer details are depicted in Figure 15 .

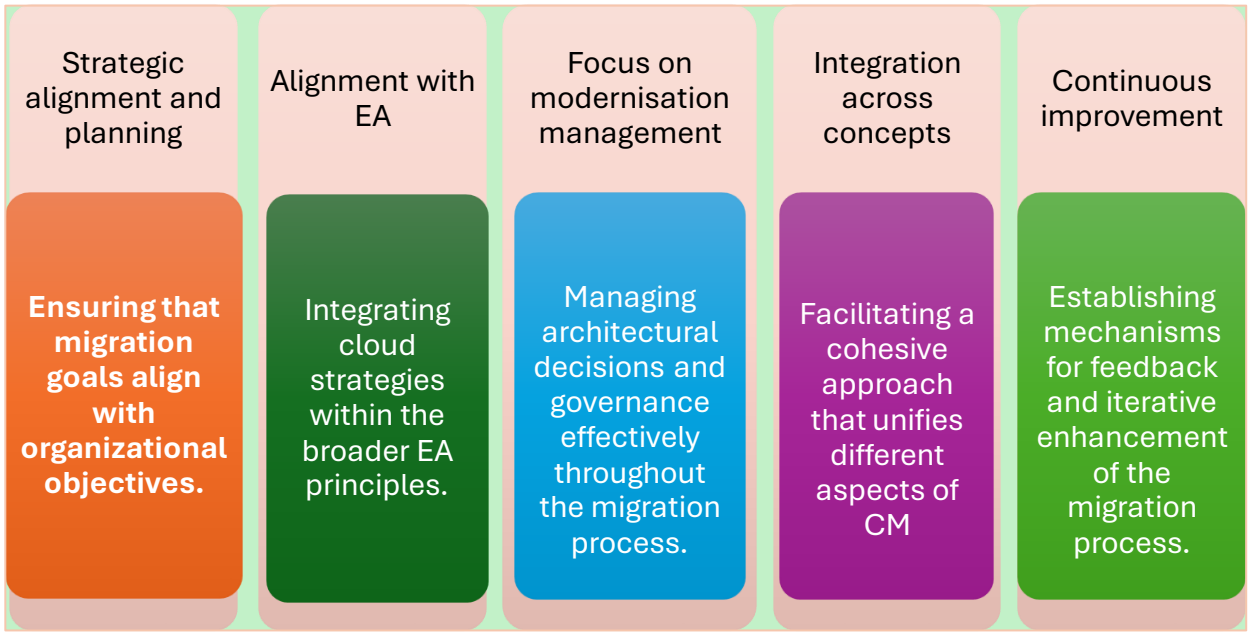

Figure 14 The High-Level View of ACMF (collated by the researcher)

A detailed view of the proposed comprehensive framework is outlined in **Figure 15**. The diagram captures all the details that constitute each phase of the framework.

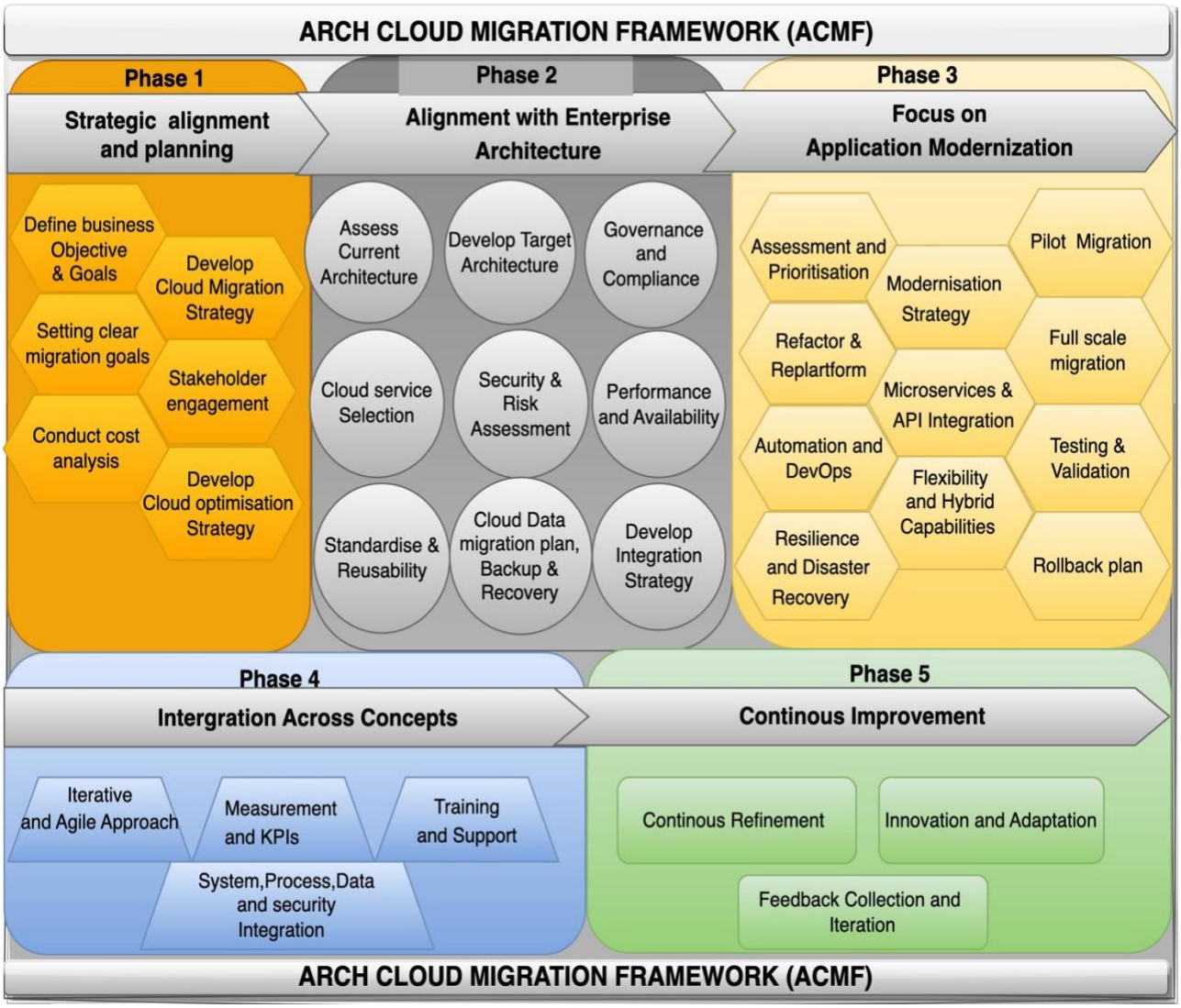

Figure 15 ACMF(collated by the researcher)

As illustrated in Figure 15 it is noted that the proposed ACMF comprises of five phases , each of the phase consist of series of steps. Detailed description of every step is provided in section 4.2.1 up to 4.2.5.

4.5 Framework execution procedure

To support the practical application of the arch CM framework, Table 1 outlines the execution procedure, including the outputs, dependencies, and sequence of activities associated with each phase.

Phase	Output	Mandatory	Dependency
Phase 1: Strategic Alignment and Planning	CM strategy and Roadmap	Yes	None
Phase 2: Alignment with EA	Target EA blueprint	Yes	Phase 1
Phase 3: Focus on AM	AM plan	Yes	Phase 2
Phase 4: Integration Across Concepts	Transformation enablement and performance assessment report	Yes	Phase 3
Phase 5: Continuous Improvement	Continuous improvement and lessons learned report	Yes	Phase 4

Table 1. ACMF Execution procedure

The framework is designed to be executed sequentially, with the outputs generated in each phase forming the foundation to subsequent phases. Consequently, completion of each phase is required before progressing to the next phase. Although iterative refinement may occur, all five phases are considered mandatory to ensure effective alignment between EA, CM, and AM.

4.6 Conclusion

Organisations encounter various challenges when they migrate systems and applications to the cloud without a structured comprehensive framework. Migration issues such as data security vulnerabilities, compatibility concerns with existing systems, and lack of standardised processes can impede a smooth migration transition. A proposed CM Framework provides a systematic approach that addresses these challenges by offering guidelines, procedures, and best practices for organisations to follow during migration projects. By having a well-defined framework in place, organisations can successfully adopt cloud services, with minimal disruptions to the operations.

5 Data analysis and findings

5.1 Introduction

The primary focus of this Chapter is the analysis of data that was collected from the panel of experts who completed the proposed ACMF evaluation questionnaire. The Chapter also presented the objectives of the study, with reference to the descriptive and inferential results. The map of this Chapter is depicted in Figure 16.

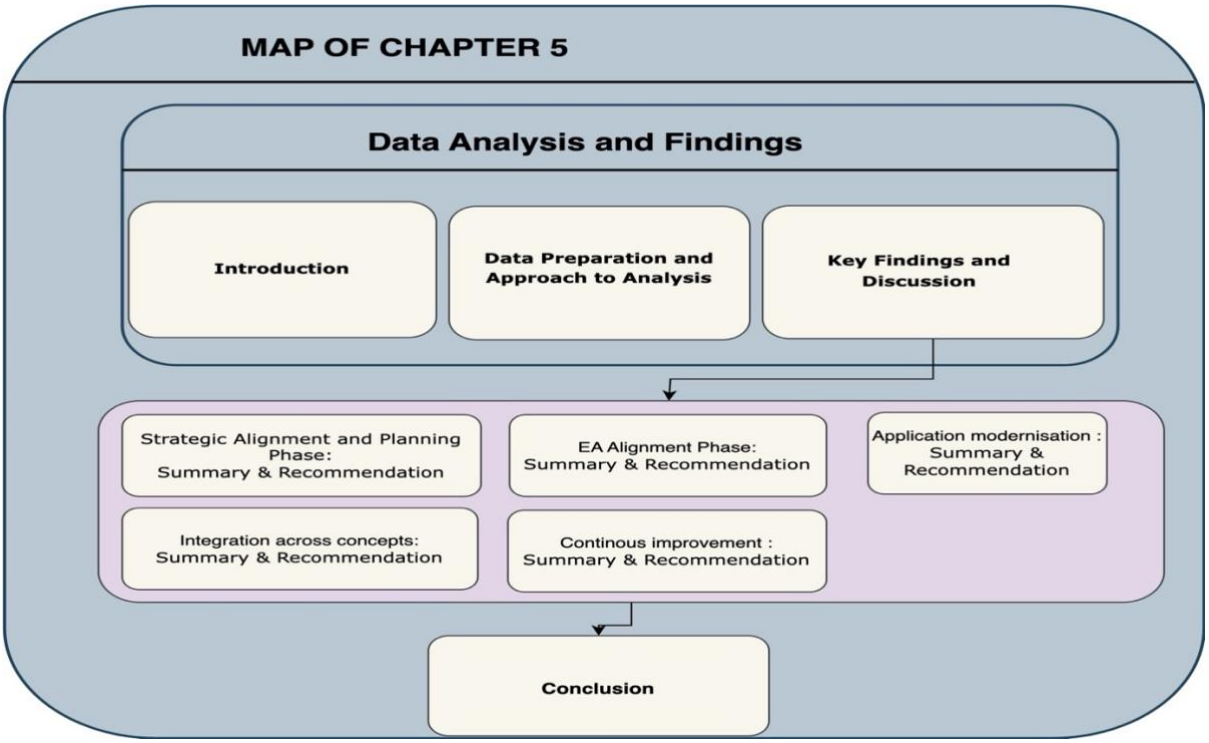

Figure 16 Map of Chapter 5

5.2 Data preparation and approach to analysis

The raw data were collected from the expert panel using a questionnaire. The evaluation results were exported onto Microsoft Excel for analysis and statistical processing. A rule-based manual data cleaning approach was applied using Excel built-in functions. This process included discarding duplicates and removing white spaces, rectifying inconsistent and addressing missing values through conditional logic (e.g., “if” statements). Further, data validation techniques such as filters and conditional formatting were also used to check for anomalies. The data validation helped to ensure that the dataset was accurate, complete, and ready for analysis.

5.3 Key findings and discussion

Strategic alignment and planning phase

The first question under this phase was:

“How effectively does this section outline key strategic alignment components?”

The aim of the question was to assess whether the architectural engagement adequately communicated issues in the strategic alignment areas. The results, which pertain to the effectiveness of these components, are shown below in Figure 17.

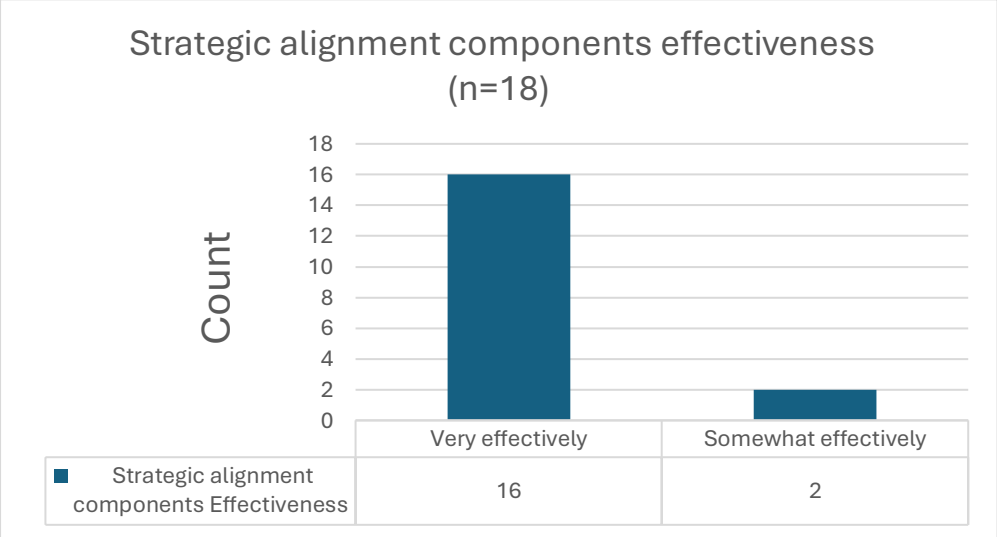

Figure 17 Effectiveness of strategic alignment components

In Figure 17 it is noted that out of 18 respondents, a large majority (n = 16, 88.9%) rated the section which pertains to each of the components of strategic alignment “very effective”. The rest (11.1%) rated them as “somewhat effective”. Importantly, no respondent rated the section as “ineffective” or “not at all effective”. The results show

that the experts had a highly positive perception of this aspect, in terms of its clarity and comprehensiveness. The second question from this phase required the experts to respond in-line with the statement: **"This section provides sufficient detail on strategic alignment features."**

The statement sought to gauge perceptions on comprehensiveness and whether the participants thought they had been given enough information to enable them to capture the features of strategic alignment that were presented to them. The responses, which pertain to the degree of the comprehensiveness of these features, are shown in Figure 18 below.

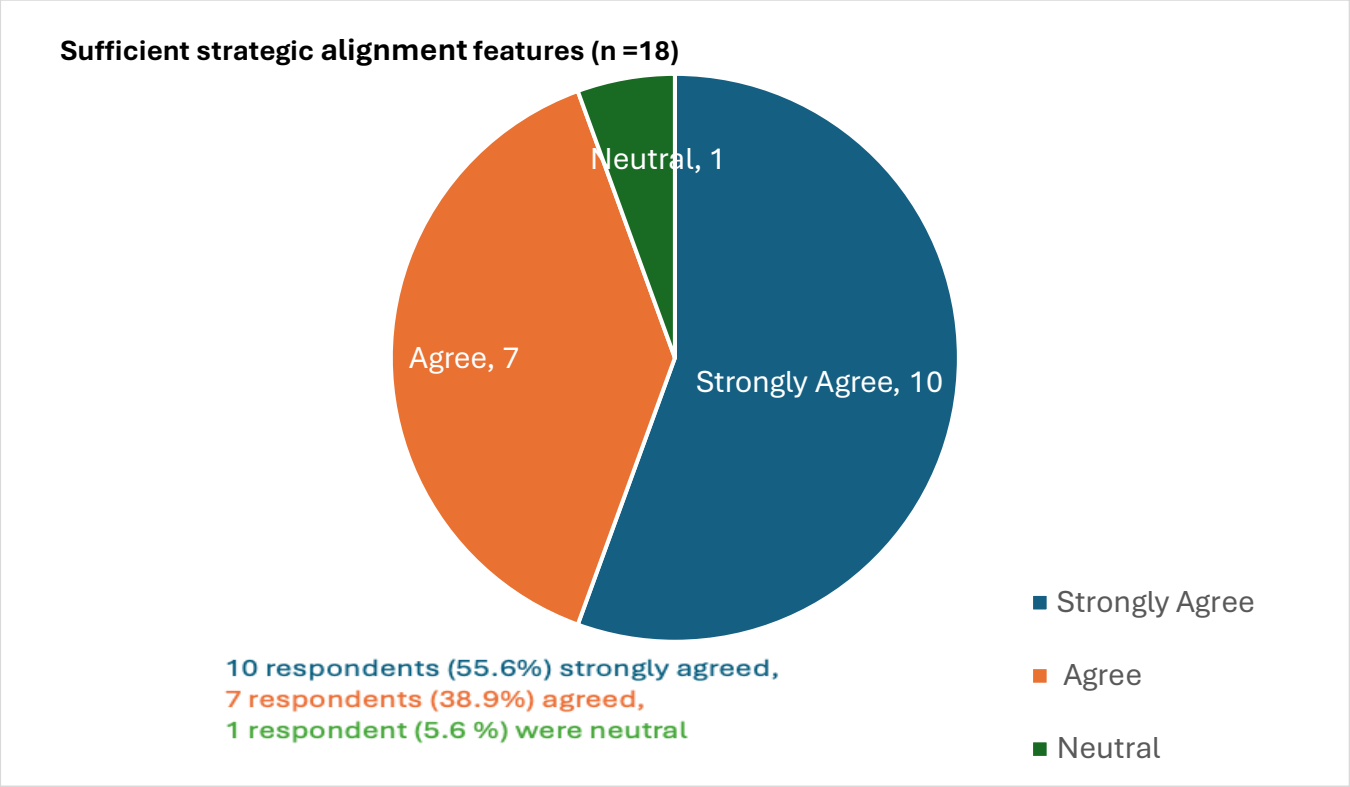

Figure 18 Strategic alignment features

In Figure 18 it is indicated that 94.5% of the survey respondents were satisfied with the given details, with at least half of them expressing strong agreement to this opinion. This suggests that the section was informative and the experts had also sufficiently detailed it to complement their understanding of strategic alignment. The third question used in this phase was open-ended and it was phrased as follows: **"What additional features do you recommend for inclusion in this section?"**

The objective of this question involved evaluating the experts' perceptions on the completeness and adequacy of the content provided in the prospective strategic alignment planning phase of the proposed ACMF. It aimed to identify any important gaps and collect qualitative insights for possible improvements to ensure improved strategic alignment in EA development planning. Figure 19 below is a visual representation of the respondents' recommendations on the additional features of the strategic alignment and planning phase.

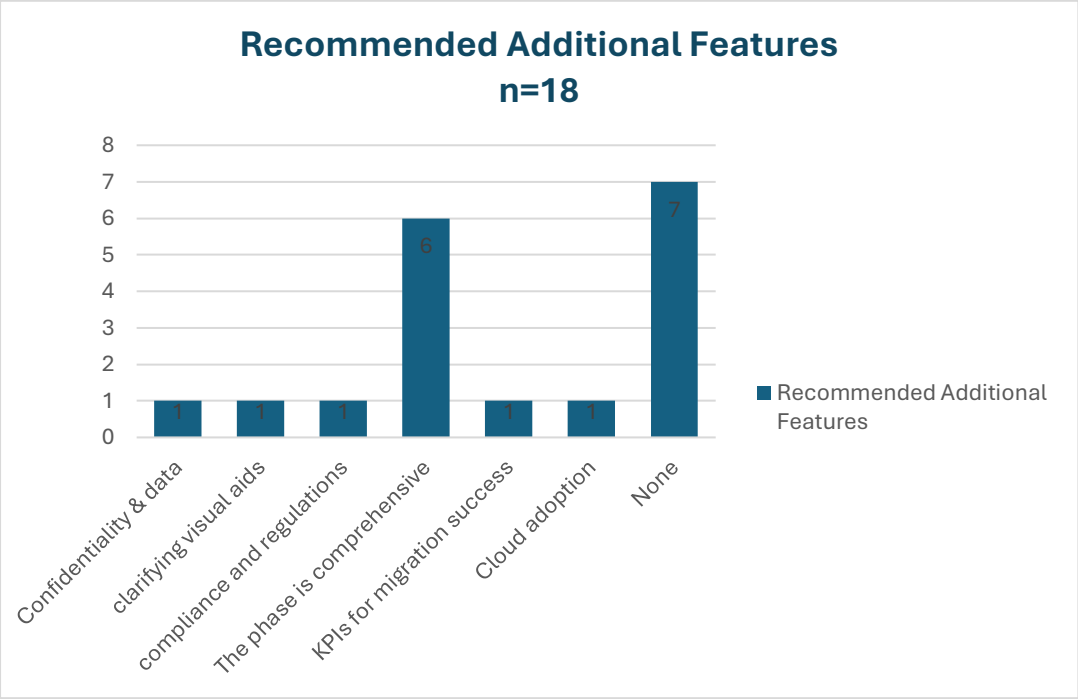

Figure 19 Recommendations for strategic alignment phase

Eighteen responses were collected, and they were thematically coded and organised into recurring suggestions, along with comments indicating no additional recommendations**.** The predominant theme that was expressed by six participants (33.3%) was that the strategic alignment and planning phase was already comprehensive. This reflected overall satisfaction with the content. Seven participants (38.89%) explicitly indicated that they had further recommendations**.**

Among the remaining responses (n= 18), several respondents proposed specific enhancements, which were aimed at improving the clarity, governance, and strategic significance of the section.

These enhancements included:

- Confidentiality and data considerations (n = 1)
- Clarifying visual aids (n = 1)
- Compliance and regulatory content (n = 1)
- KPIs for migration success (n = 1)
- Cloud adoption strategies (n = 1)

The above-stated recommendations for enhancement show how the section could be improved via visual elements, governance alignment, and measurable success criteria.

Summary and recommendation: Strategic alignment and planning phase

In general, the respondents had positive impressions towards Strategic alignment and planning section. The majority of the respondents rated it as very effective (88.9%) and detailed enough (94.5%), which reflected a strong alignment with the business strategy. Most of the suggestions for improvement were limited in nature, as the portion above was already extensive, according to many respondents. It should be noted that some respondents suggested improvements as KPIs for migration success, including cloud adoption strategy and regulatory aspect.

Recommendation:

Although the strategic alignment and planning section generated positive feedback from the expert panel of evaluators, their feedback highlighted the need for incorporating performance indicators, visualisations, and citations to compliance and data governance, to reinforce the strategic alignment narrative and support performance.

5.3.2 Alignment with EA phase

To consider the extent to which focus on EA related alignment with the wider EA framework was presented within this section, the respondents were asked the following question:

“How effective is this section in demonstrating alignment with the overall EA?”

This question was designed to measure the perceived effectiveness of architectural alignment with CM, and had a response range from “Very Effective” to “Very Ineffective”. Figure 20 illustrates the overall efficiency of general EA and how this section fits into it.

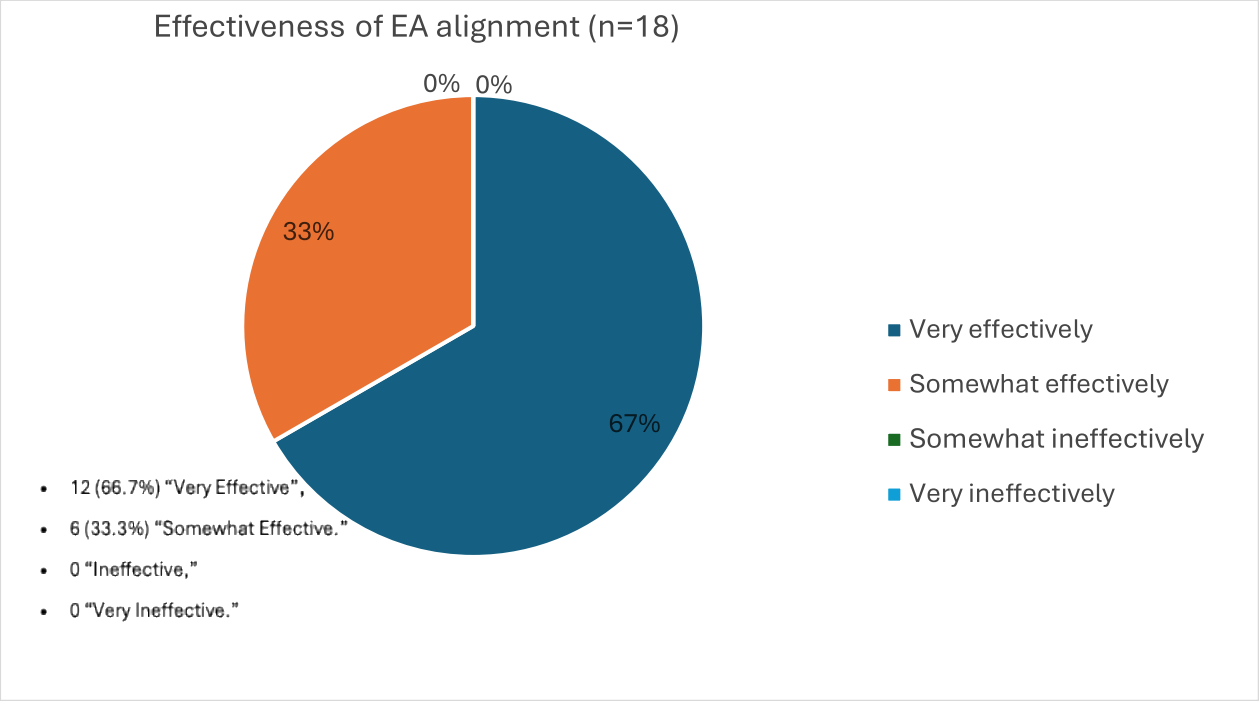

Figure 20 Effectiveness of EA alignment

One of the key findings showed a positive perception of this section, regarding alignment with its EA principles. 66.7% of the respondents said they thought that this section was very effective in aligning the principles of EA. However, the rest of the participants stated that it was somewhat effective, which suggested that there was room for improvement.

The second question in the EA alignment section required the experts to evaluate if the architectural components in the segment complied with the principles and standards of EA. The question was phrased as follows:

“The architectural components in this section are consistent with our EA principles and standards.”

The above question was designed to investigate the extent to which the EA section of ACMF complied with the well-established architectural governance structures, regulations, and technical standards.

Figure 21 illustrates a consistent response distribution of a high percentage of agreement or clear agreement across respondents.

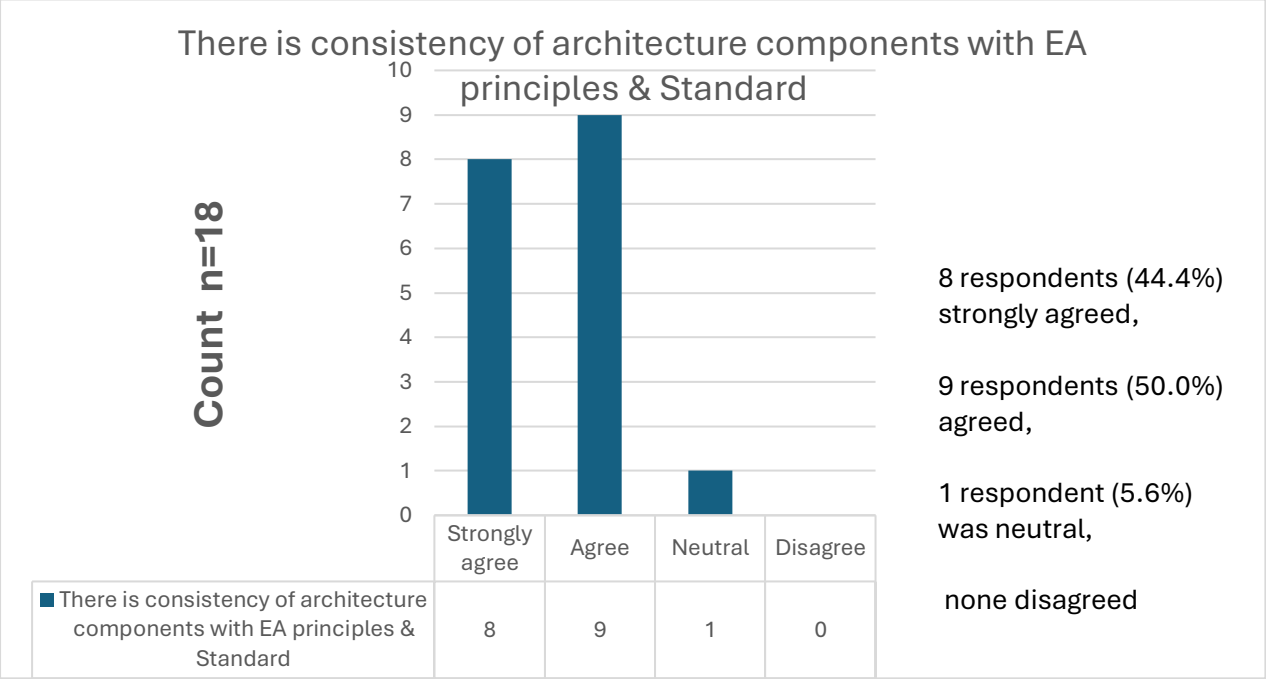

Figure 21 Components consistency to EA principles and standards

These findings indicated a strong perception consistency, where present architecture components were seen to be in alignment with EA standards at an organisational level. The absence of negative sentiments supported the notion that the adherence to EA principles was legitimate.

In question 3 of this section, the experts were instructed to highlight the extent to which they agreed with the below statement:

"This section sufficiently incorporated EA principles tailored for successful CM."

This question focused on measuring the scale to which architectural content followed the principles of EA that underpin CM such as modularity, scalability, and alignment with interoperability and governance.

Figure 22 illustrates the distribution of the responses that mirror consensus among the respondents who have indeed successfully incorporated EA theory concepts to support CM.

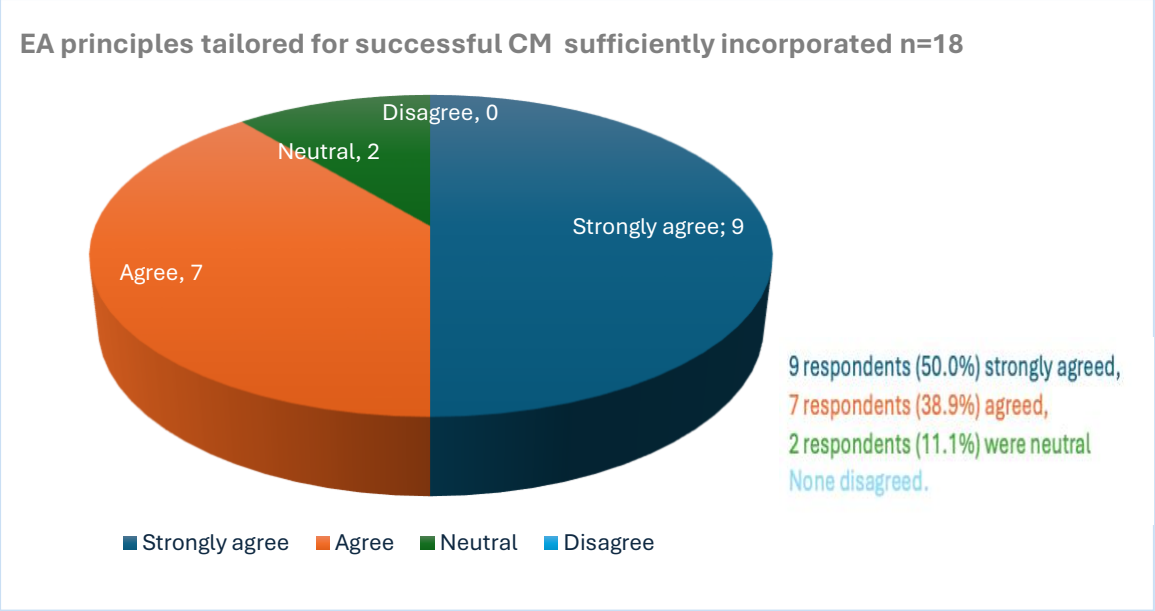

Figure 22 EA principles sufficiently tailored for CM

These findings generally give a positive assessment of the appropriateness of the CM-related EA concepts that were included herein. 88.9% of the respondents agreed that there was enough architectural content to provide effective support to the key elements of cloud adoption and migration efforts.

Below is the final question of this phase:

"What additional features do you recommend being added to enhance the EA alignment in this section?"

This question was designed to identify gaps or enhancement opportunities in the architectural content pertaining to EA alignment**.** Eighteen responses were received and grouped by theme.

In Figure 23 there is depiction of the distribution of the recommended features, which emphasise the need for the integration of more human readiness, compliance frameworks**,** and cloud-native approaches, to achieve a more holistic and future-ready EA design.

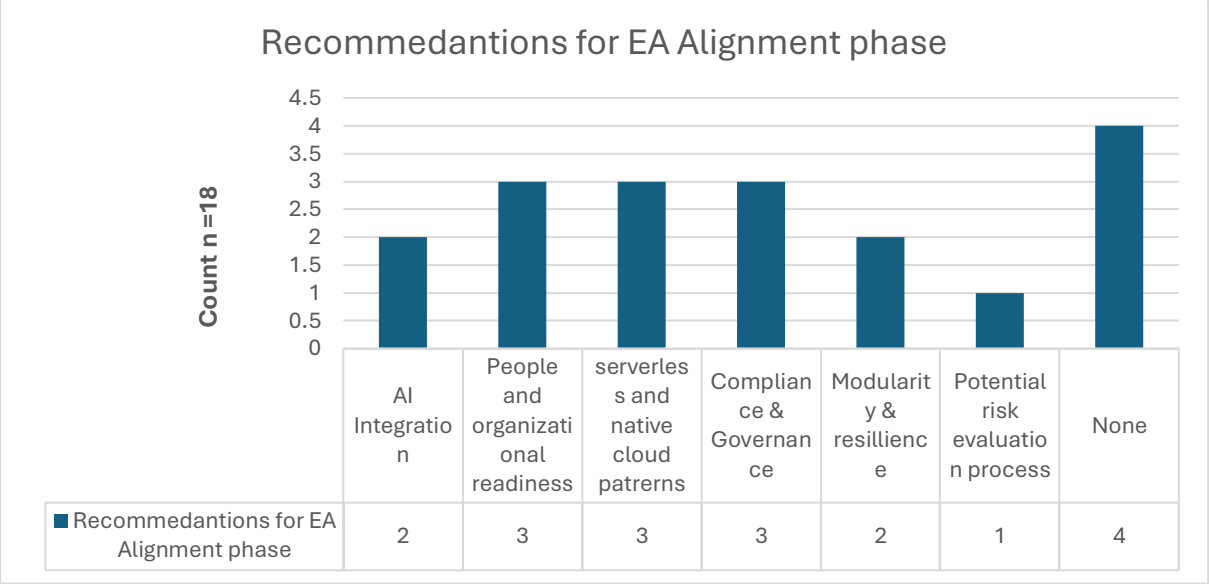

Figure 23 EA alignment recommendations

Most of the recommendations focused on the following:

- People and organisational readiness (n = 3),
- Serverless and native cloud patterns (n = 3),
- Compliance and governance mechanisms (n = 3),
- AI integration (n = 2),
- Modularity and resilience (n = 2), and
- Potential risk evaluation processes (n = 1).

Notably, four respondents (22.2%) expressed that additional features were not necessary, thereby indicating overall satisfaction with the existing content.

Summary and recommendation: EA

The findings from this phase showed a broadly positive opinion on the alignment of this section with EA principles. 94.4% agreed with or strongly agreed that the section closely adhered to the larger EA framework and organisation-wide expectations. Regarding CM, 88.9% of the participants indicated that EA principles were adequately integrated to facilitate successful migration strategies. These results suggest that the section effectively covered the foundational architectural governance and cloud computing considerations.

The respondents provided insightful feedback, notably the suggestions to embed elements such as organisational readiness, serverless/cloud-native patterns, compliance and governance measures, and AI integration. Although 22.2% of the respondents thought that changes were not necessary, numerous suggestions offered ways to increase architectural resiliency and adaptability.

Recommendation:

EA alignment can be reinforced further by incorporating aspects that relate to organisational change management, evolving cloud trends, regulatory compliance, and technological innovations (such as AI). This way the architecture will be future-oriented and capable of catering for the technical and human aspects of enterprise transformation.

6 Recommendations and conclusion

6.1 Introduction

The accomplishment of this study is described in detail on Section 6.2, while section 6.3 presents the responses to the research questions. Section 6.4 provide a summary of the recommendations and opportunities of research in the future. The conclusion of the study is outlined in section 6.5. The structure of this Chapter is illustrated in **Figure 24**, below.

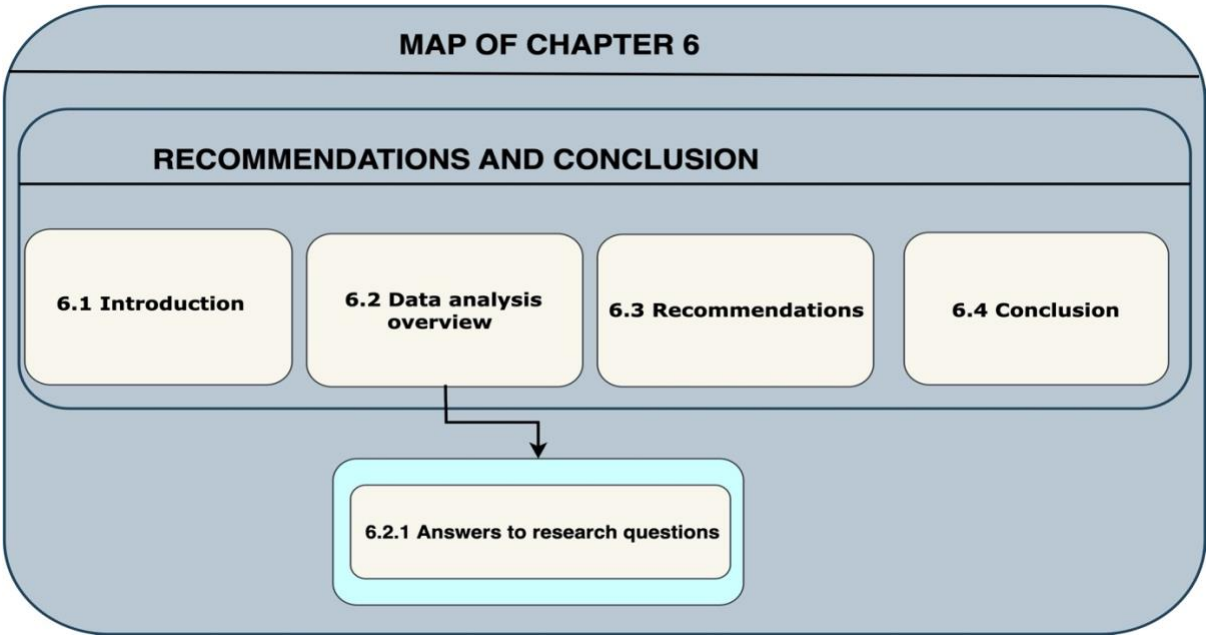

Figure 24 Map of Chapter 6

6.2 Data analysis overview

The study focused on the development of a proposed framework for the facilitation of CM and EA as enablers for the CM. The research included to the development of a proposed comprehensive framework named ACMF. The proposed framework consists of five phases namely: *Strategic Alignment and Planning, Alignment with EA, Emphasis on Application Modernization, Integration across Concepts, and Continuous Improvement and Feedback Loop*.

It is envisioned that the proposed ACMF would provide businesses with a clear and comprehensive approach to ensure a strategically planned, efficiently executed, and continuously optimised CM process. This is considered as a significant contribution to the field of information technology and cloud computing. The proposed framework will help organisations to understand the complexities involved in transforming legacy systems into cloud-enabled environments, thereby making it possible to assure that these steps are consistent with the strategic goals. Ultimately, this can improve operational efficiency and reduce migration risks.

The proposed framework is a synthesis of the best practices in CM, EA, and AM. This alignment ensures that the proposed framework is not only academically robust, but it is also practically applicable and capable of providing businesses with proven strategies for success. The framework provides the best practices in CM, EA, and AM. This level of alignment ensures that the framework is not solely academic, but also practically relevant and provides companies with pre-tested success strategies. In the process of CM, organisations encounter significant challenges namely: misalignment between business objectives and IT infrastructure; complexities in AM; and a myriad of technical and business integration complexities.

The proposed framework provides practical steps that help organisations to mitigate the risks of CM. Reducing these risks enables organisations to transition to the cloud more smoothly, with fewer interruptions to their operations. The findings of the study demonstrate the importance of focusing on strategic alignment, as it is pivotal to the successful implementation of this framework. Strategic alignment also ensures that CM initiatives are grounded

within the broader business goal(s) of an organisation. Further business aims should be aligned with cloud strategies, while all key stakeholders should actively participate in the CM planning phase. By embedding a framework for alignment with business goals, companies might see higher levels of coherence between financial investments in IT and their corporate goals, thereby aiding a smooth migration to the cloud and enabling direct and measurable business outcomes.

In addition, a concept named continuous improvement feedback loop was integrated into the proposed framework. This was designed to enable continuous optimisation of cloud landscape post-migration. By constantly improving on business needs, organisations can ensure that the cloud setup can keep pace with new business realities and technology. This allows the business entity to remain agile and competitive. The proposed framework is applicable to both small and large businesses that intend to migrate to the cloud. Having scalability allows the proposed framework to be applied to any business at any scale beyond levels that are relevant to research, thereby making it a highly useful tool for businesses that are planning to migrate to cloud.

AM is an essential step in the CM process. This necessitates the development of practical ways to redesign and adapt to the new cloud setup on existing legacy systems. Focusing on this approach assists organizations to fine-tune their applications to be cloud-ready, consequently boosting performance, scalability and cost-efficiency. Moreover, this study identified significant implications for CM strategies and knowledge across general literature and best practices, which are especially relevant to the context of cloud technologies as they fit into existing EA designs and business strategies.

6.2.1 Research questions answers.

Chapters 1 and 2 addressed the objectives and research questions. The first objective was to establish and examine the link between the three concepts namely: EA, CM and AM. The below question below was revisited.

Question 1: How do the three concepts (EA, CM and AM) align?

The literature increasingly recognises the relationship between AM, CM and EA as essential components for successful digital transformation. EA offers the strategic alignment and governance framework through which IT projects are aligned with organisational priorities. CM supports the delivery of that vision with the right scalable infrastructure and AM. Further, the operational link which modernises legacy systems, ensures that old systems can run on cloud environments and architectural patterns that would enable them to work on modern software.

These three aspects of EA, CM, and AM do not work in isolation, but they operate collaboratively around each other, with a single common plan for determining and executing CM. EA spells out the transformation objectives and the reasons for transformation ("what" and "why"); cloud infrastructure lays the foundation ("where"); and modernisation ensures compatibility and optimisation ("how"). When combined, these three elements enable organisations to implement holistic and consistent transformation efforts that reduce technical debt, while building a more dynamic, resilient and strategically aligned IT environment.

The second objective was to evaluate the state of existing CM frameworks and the prerequisites for efficient CM. The question below was reviewed to meet this goal.

Question 2: What is the status quo of existing CM frameworks?

The findings of this study showed that existing CM frameworks were primarily technical-oriented, and they focused on specific stages like assessment, migration, and optimisation. However, these frameworks are rarely integrated with EA, AM, and strategic alignment. As a result, these frameworks typically overlook crucial business and architectural factors that are vital to continued success. The findings point to an important space for the improvement of existing frameworks: a more comprehensive, sequential and phased approach that integrates strategic alignment, EA, and modernisation as basic dimensions of the migration process. This highlights the importance of stronger frameworks, like the one that was introduced in this study, which encompass both technical deployment and strategic alignment at the business level.

Question 3: What is required as pre- and core-requisite for CM?

This research identifies several key preconditions that are needed for CM. These include clearly defined business objectives; stakeholder engagement; readiness evaluations; and governance structures. The core needs that were identified during the investigation include: portfolio review of legacy AM; alignment of security with compliance requirements, as well as monitoring performance. These gaps highlight the for a more comprehensive framework, like the one that was proposed in this paper, which unites technical and strategic components, thereby enabling effective and efficient CM.

Question 4: What are the metrics used to determine the success of CM?

These findings highlight the impact of CM, based on technical, operational, and strategic metrics. This indicates key metrics such as cost reduction, system performance (latency and uptime), scalability, and progress in AM. The study established that success should focus on aligning migration with strategic organisational goals that can deliver measurable business value, rather than merely concentrating on technical outcomes. **The final objective was to establish a detailed framework to facilitate CM. This was accomplished through the creation of an ACMF using DSR methodology.**

6.3 The future research recommendations

The future research suggestions and opportunities include:

- Eliminating manual migration and monitoring a very burdensome, error-prone task by looking into exploring Artificial Intelligence (AI) or Machine Learning (ML) for workload analysis, optimisation, and predictive maintenance. This helps to reduce complexity, make things simpler, improve accuracy, and speed up migration.
- Embed AI in strategic planning and application evaluation for automated decision-making. Such integration would reduce planning challenges and allow faster and better-informed decision-making by creating intelligent Decision Support Systems (DSS) to select migration strategies (such as lift-and-shift or re-platforming), based on application characteristics.

- Recognising that not all businesses are at the same readiness level for CM, therefore, there is need for a holistic model that incorporates basic, intermediate and advanced levels. Such a model helps businesses in assessing their current preparedness and how they can progress through the framework.
- Evaluate how CM can be related, affects, or contributes to environmental sustainability with respect to eco-friendliness, including energy efficiency statistics and carbon footprint tracking within the framework. Through this emphasis, it will be possible to raise awareness of green considerations and decision-making processes which align with ESG objectives.
- Develop a security readiness checklist as part of the framework for enterprises to proactively defend against threats which may arise while doing migration or post-migrate. The project will reinforce security through a full range of assessments and controls.
- CM is not just migration in technology, but it also transforms people, processes, culture, and strategy. The organisational change management (OCM) approach is recommended, and it should be embedded as a sustained, overarching element across all phases, particularly between strategic planning and AM.
- Whilst the proposed framework is deemed usable , the next future research requires implementation details in the given scenarios.

6.4 Conclusions

This research mainly addressed the gap in the lack of a comprehensive framework which ACMF was created. This five-phased approach fills existing gaps through integrating essential prerequisites and aligning migration strategies with company goals. The expert feedback validated that this framework clarifies CM, aligns it with business aims and yields more successful and sustainable results. Consequently, the proposed ACMF, can help businesses to mitigate risks, maximise efficiency, and confirm that cloud initiatives can produce measurable business value.

The selected approach addresses both technical implementation and organisational readiness, resulting in more successful and sustainable migration outcomes. Optimising the CM framework involves practical improvements

(automation, DevOps practices, KPIs, and more), as well as strategic improvements (AI integration along with governance frameworks dealing with compliance with risk). Future research should seek to validate, extend, and adapt this framework, while keeping its relevance. My future research will include the investigation of the practical implementation of the proposed framework within organisational settings to evaluate its applicability, effectiveness, and business value.

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