EMPIRICAL EVALUATION OF FINOPS FRAMEWORK FOR SUSTAINABLE CLOUD ENGINEERING

SYNOPSIS

For the degree of
Doctor of Philosophy

in

Computer Science

Registration No. PHD/2019-20/0062

Submitted to

SIKKIM PROFESSIONAL UNIVERSITY
TADONG, GANGTOK, SIKKIM (INDIA)

Supervisor:

Dr. Vishal Khatri

Research Scholar:

Prasanjit Singh

2020

DECLARATION BY THE SCHOLAR

I hereby declare that work reported in the Ph.D thesis entitled **"Empirical Evaluation of FinOps Framework for Sustainable Cloud Engineering."** submitted at **Sikkim Professional University Tadong, Gangtok, Sikkim India** is an authentic record of my work carried out under the supervision of Dr. Vishal Khatri. I have not submitted this work elsewhere for any other degree or diploma. I am fully responsible for the contents of the contents of my Ph.D Thesis.

Place:- SPU, Tadong, Gangtok Sikkim (India)

Date : …… Signature of Research Scholar

Name: **Prasanjit Singh**

PHD/2019-20/0062

SUPERVISOR'S CERTIFICATE

This is to certify that the work reported in the Ph.D. thesis entitled **"Empirical Evaluation of FinOps Framework for Sustainable Cloud Engineering."**, submitted by **Prasanjit Singh** at **Sikkim Professional University Tadong, Gangtok, Sikkim India** is a bonafide record of his / her original work carried out under my supervision. This work has not been submitted elsewhere for any other degree or diploma.

Place : - Sikkim, India

Date :- .....

Signature of the supervisor

Dr. Vishal Khatri

TABLE OF CONTENTS

1. INTRODUCTION

In order to maximise profits and minimise upfront costs, most modern information and communications technology (ICT) solutions are increasingly moving services, applications, and databases into a cloud computing environment. One of the aspects that is driving this shift is the "pay as you go" payment approach that cloud computing providers offer. This strategy enables businesses to reduce the amount of capital investment they put into their own infrastructure. If a corporation wanted to maintain their own infrastructure, it would tie up a large amount of capital and time before they could build services comparable to those supplied by public cloud providers. Since the introduction of this payment mechanism by a variety of cloud computing companies, there has been mounting data demonstrating the benefits of employing its use (Odun-Ayo et al., 2018).

The process of determining which company offers the most reliable cloud computing services is not a simple one. In addition to the financial investment, firms will need to think about the amount of time that will be spent on the process. It can be challenging for businesses, especially those with legacy systems, to establish which migration plan will be the most successful when using cloud computing. Before picking the correct vendor, businesses need to consider not only the original investment but also the ongoing maintenance expenditures in order to evaluate cost effectiveness, performance, and upkeep.

The high costs that were plaguing a variety of different businesses gave rise to the idea that would later become known as "FinOps." Monitoring cost services are now being created as part of an effort to save costs in the cloud and demonstrate the viability of the FinOps idea. Companies have a tendency to improve the situations and problems they are facing as a result of these tools, which also provide a single management interface that facilitates cross functional collaboration between departments such as Engineering, Finance, and Delivery, which in turn enables financial control and predictability to be enhanced and costs to be optimised. In addition, these tools tend to provide a single management interface that facilitates cross functional collaboration between departments such as Engineering, Finance, and Delivery.

1.1 OVERVIEW OF CLOUD COMPUTING:

In today's rapidly evolving digital landscape, the demand for scalable and flexible computing resources has reached unprecedented levels. As businesses and individuals increasingly rely on data-driven technologies, the need to store, process, and access vast amounts of information in a cost-effective and efficient manner has become paramount. In response to these challenges, cloud computing has emerged as a transformative paradigm, revolutionizing the way we perceive and utilize computing resources.

Cloud computing represents a paradigm shift in the field of information technology, enabling ubiquitous access to shared pools of configurable resources over the Internet. It offers a compelling alternative to traditional on-premises infrastructure by providing on-demand availability of computing power, storage capacity, and software services. This paradigm not only delivers unparalleled scalability and flexibility but also alleviates the burden of managing complex hardware and software setups.

The customer relationship management system offered by Salesforce, public cloud services offered by Amazon Web Services (AWS), Google Cloud Platform (GCP), and Microsoft Azure are all instances of cloud computing. Users are able to easily configure and provision computing resources over the Internet using servers, storage, hosting services, and other services by utilising cloud computing. According to Rashid and Chaturvedi (2019), cloud service providers are the ones who offer these kinds of services, and the consumer is required to put in very little effort (Rashid & Chaturvedi, 2019). The overall concept of cloud computing can be illustrated by following figure.

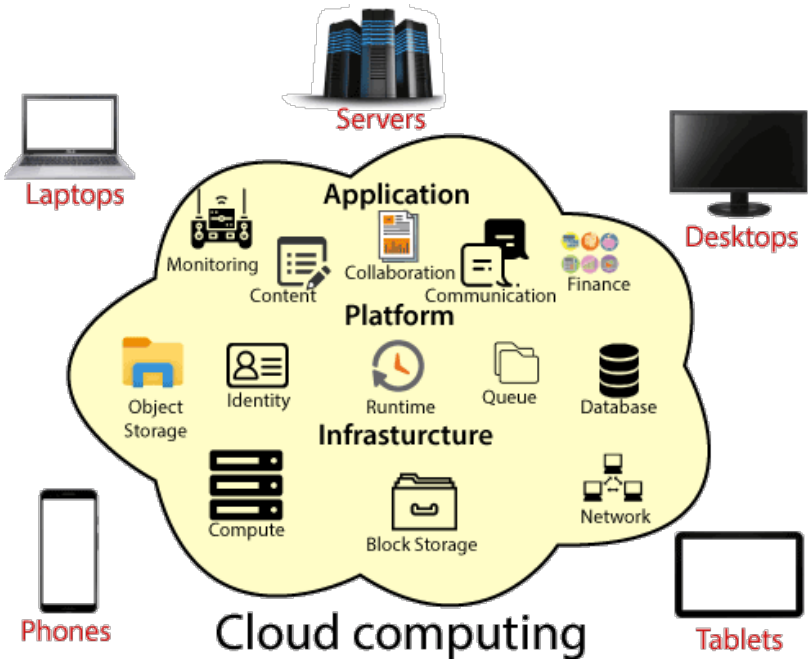

Figure 1.1: Overview of Cloud computing (Duan, 2017)

Cloud computing can be broken down into three distinct subcategories, which are public cloud, private cloud, and hybrid cloud, as a result of the rapid pace of technological advancement and the growing demand for information technology in today's world. The term "public cloud" refers to a type of cloud computing that makes its services available to any and all Internet users who want to deploy their own apps or projects with a minimum of administrative oversight. A private cloud, in contrast to a public cloud, provides businesses, even those of an enterprise size, with controlled access, dedicated data centres, and a private network in order to host the services that are required by that particular company (Halabi & Bellaiche, 2017). A hybrid cloud is created by combining public and private cloud services, together with the necessary instruments and hardware to bridge the gap between them. Creating a unified, automated, and scalable environment that takes use of everything that public cloud structures will offer while yet maintaining control over mission-critical data is the goal of the hybrid cloud. This environment will take advantage of all that the public cloud structures will offer (Cheng et al., 2018).

The majority of cloud service providers can be classified into one of four primary groups: infrastructure as a service (IaaS), platform as a service (PaaS), software and serverless computing as a service (SaaS), and data as a service (DaaS). Due to the fact that they are stacked on top of one another, these are commonly referred to as the "pile" of cloud computing. It is much simpler to accomplish one's professional goals once one is aware of the two concepts and the ways in which they differ from one another. As a result of the growing number of demands placed on the cloud computing industry, the services are currently evolving into connections that are more dynamic with contemporary architecture and technology.

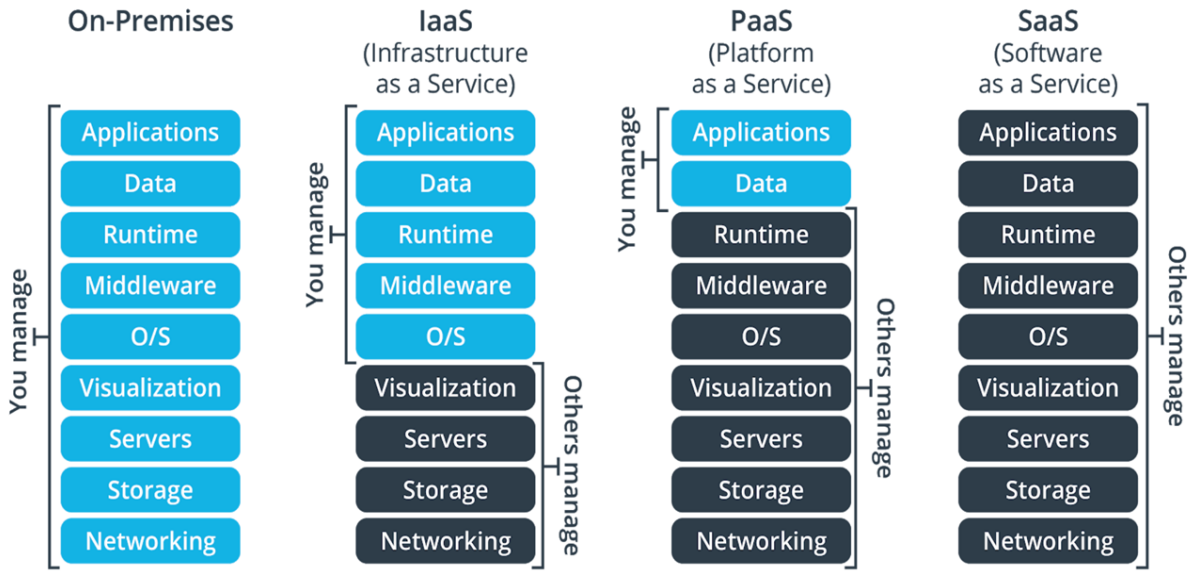

Figure 1.2: Cloud Computing Models (Joel, 2021)

Cloud computing provides the cost-effective redundancy required to protect data against system failures and the private storage space required to access data and applications in the event of a local outage or disaster. As a result, disaster recovery and job continuity have always been important aspects of cloud computing. This is because cloud computing provides the space required to access data and applications in the event of a local outage or disaster. The best cloud service providers all provide a disaster recovery as a service option for their customers.

All of these service models are currently being utilised by a variety of sectors within the application systems, mobile commerce applications, and everyday operating service applications that they have developed. The suppliers of cloud computing services make it easy for organisations to select the service models that are tailored to match their specific requirements.

The vast majority of companies are currently addressing their information technology needs, ranging from tiny to medium-sized operations, with some flavour of cloud computing. Prospective adopters of cloud computing want to make an objective decision about which cloud solution is best for their companies now that there are more cloud alternatives accessible. This result is dependent on a wide variety of factors, such as the accessibility and usage of the system, its level of safety, its cost, its return on investment (ROI), the reputation

of the cloud provider, and many more. The repercussions of these factors will continue to have an effect on business practises for many years to come (Duan, 2017).

1.2 CURRENT CHALLENGES IN CLOUD:

Since the public cloud's ascent to prominence, the cloud computing industry has been aggressively marketing hybrid cloud solutions to corporate customers. Taking advantage of the fact that not all work will be moved to the public cloud, a number of cloud vendors and system integrators have made the promise to integrate this organization's information centre and the public cloud in a smooth manner. Despite this, the integration of on-premises systems with cloud storage continues to present a substantial difficulty as well as opportunity.

The most pressing issues facing businesses today and the most important subjects of conversation may be broken down into two categories: cost optimisation and security. The use of cloud technology confers several benefits to efforts, including reduced operating expenses and accelerated time to market. However, not all cloud-based programmes have sufficient safeguards in place to protect user data. 80 percent of the 12,000 cloud firms enable customers to use passwords that are insecure. If hackers got their hands on the stolen and shared password, they would have an easy time gaining access to the organization's most sensitive data (Subramanian & Jeyaraj, 2018).

1.3 THE FINOPS CONCEPT:

A public cloud structure is described as a potential future trend in the industry. Managing the costs of a single cloud provider may be straightforward, but managing the costs of many cloud service providers may be more difficult. In a situation like this, billing and monitoring systems that are agnostic start to look more appealing. Creating a tool that could be utilised across multiple departments by all end users and for which a technical background is not required would be the greatest approach for a company to make the most efficient and beneficial technology investments. This would be the case if the tool were created. Organisations now have access to FinOps, which is a mix of the terms finance and operations. Concepts can be interpreted in a variety of ways depending on the auditor and the edition. According to the FinOps Foundation (2021) the ultimate goal of FinOps is to maximise the amount of value that can be brought to enterprises through collaboration between organisational teams and technological teams.

The term "Financial Operations" refers to a collection of best practises and procedures that are used to manage and optimise cloud computing expenses. Organisations are able to maximise the value of their cloud investment and optimise their spending if they align the financial and operational components of their cloud usage. In terms of financial operations, there is something known as the FinOps Foundation, the aim of which is to undertake research and incorporate financial operations ideas into a wide range of cost management products. The FinOps Foundation is a not-for-profit trade organisation, and its membership roster includes a number of well-known personalities in the information technology sector. Joseph Daly, who is the director of cloud optimisation services at Nationwide, is one of several professionals who have comparable positions in companies such as Atlassian, Autodesk, and Spotify.

The optimisation of costs, visibility of those costs, and governance of those costs are the focal points of a FinOps approach. This central focus is also applied to monitoring tools that are made available in public cloud settings and used in such environments. The purpose of this is to provide assistance to businesses in cutting costs related with spending on cloud computing and removing waste linked with cloud computing prices. FinOps is a framework that may be utilised by organisations in order to better the management of their cloud costs. This can be done with the intention of lowering costs, enhancing transparency, and enabling improved business decisions. Although the area of FinOps is still in its infancy, it has been gaining traction as more businesses move their workloads to the cloud and consequently more people become interested in it. FinOps may provide a framework for businesses, allowing them to optimise their cloud costs and maximise the returns on their investments.

1.4 FINOPS LIFECYCLE:

The idea of the FinOps Lifecycle was developed so that practises could be organised into a framework that organisations could utilise. It is broken up into three distinct phases, each of which real-world organisations are able to put into practise in accordance with specific protocols. It is not recommended to jump into all three phases at once but rather to crawl through each phase sequentially because each phase contains its own unique challenges and calls for a different approach. This method enables organisations to tackle the challenges of each phase consecutively rather than trying to force an all at once transformation to their cloud process. In fact, it is not suggested to jump into all three phases at once. Instead, it is

recommended to crawl through each phase sequentially. It is absolutely necessary to get experience and make contributions with a variety of teams during each phase. It is absolutely necessary to get experience and make contributions with a variety of teams during each phase. There is a set of activities that are included in each phase of the process. During these activities, a solution-focused approach is taken towards identifying the issues that are causing the increase in costs and how these issues can be fixed in a manner that is more effective. Each step does not progress in a linear order, and practitioners need to devise strategies to iterate them on a consistent basis to ensure that the life cycle develops in the way that was intended (FinOps Foundation, 2022)[1].

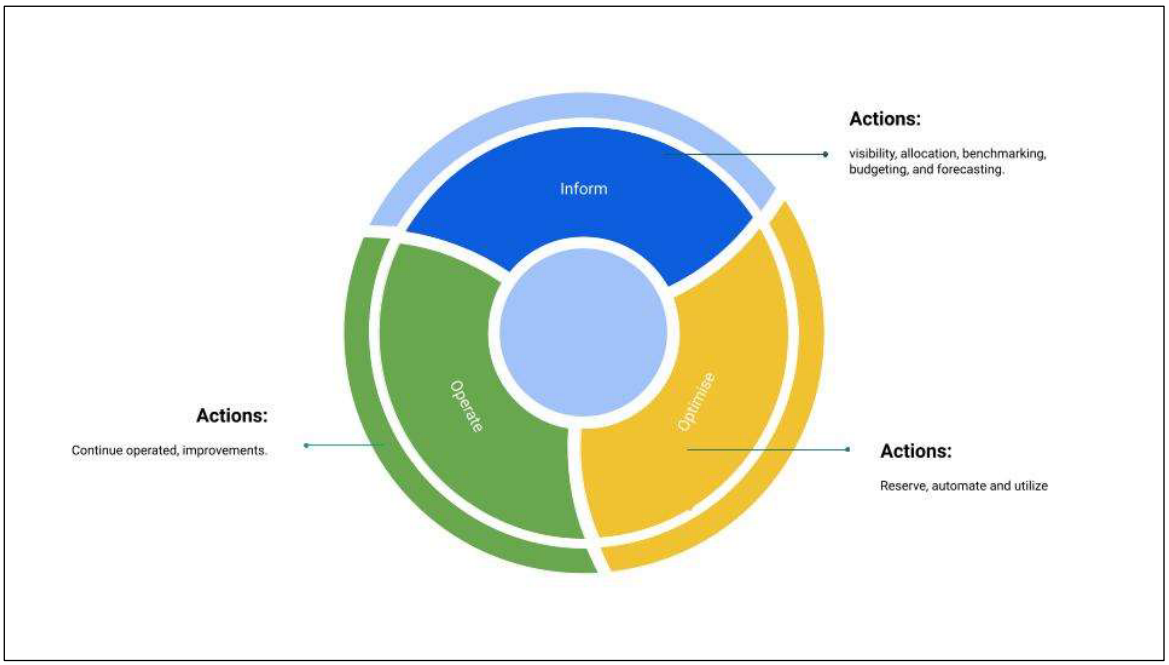

Figure 1.3: FINOPS Lifecycle (Mei, 2023)

Consumers of Enterprise Cloud services are obligated to investigate the costs associated with the entire lifetime of the cloud service. These costs should include initial migration, operations, and end-of-term ramifications, in addition to licencing implications and operational dangers. It is essential to possess a comprehensive capacity for financial management that is able to deal with multiple clouds. The establishment of a FinOps competence within the company will be of assistance in the management of these issues. A focus should be placed on the FinOps of cloud expenditures in order to reduce the expenses

[1] https://www.finops.org/introduction/what-is-finops/ . Accessed: 3 October 2022

of cloud service by hosting across many clouds. The objective of this research is to devise algorithmic approaches to cost optimisation that may be implemented in the form of models for the goal of providing efficient and dependable solutions to the problem at hand. The approach that has been suggested is to carry out a hypothetical evaluation with the purpose of presenting recommendations not only for the management of finances but also for the energy efficiency of several cloud systems. The incorporation of sustainability into the day-to-day design, development, and operational processes of cloud engineering is one way in which the knowledge of FinOps may contribute to the solution of problems associated with cloud computing. The next paragraphs include further information that elaborates on this point.

2. LITERATURE REVIEW

The objective of the research conducted by **Mei (2023)** was to investigate the ways in which cloud monitoring tools and Financial Operations (FinOps) might be combined to achieve cost optimisation in cloud systems. The purpose of this thesis is to investigate the methods and approaches utilised in FinOps, such as cost allocation, budgeting, and forecasting, as well as how these might be utilised in conjunction with cloud monitoring technologies to achieve the goal of reducing overall cloud expenses. In addition to this, the issues that may be faced by organisations when functioning in a cloud-based environment are discussed in the study. In addition to this, the research offered a summary of a multi-cloud billing monitoring tool that, from a contemporary point of view, has the potential to improve the cost optimisation strategy. According to the findings of the study, integrating FinOps and cloud monitoring technologies can give a holistic approach to cost optimisation in cloud environments; however, for this strategy to be effective, effective data management, tool integration, and team communication are required. Organisations are able to achieve cost optimisation while maintaining system performance and functionality if they implement the insights and strategies that are offered in this thesis and put them into practise.

Cloud computing, as a new format of the information industry, is the main technology and means to lead the innovation and development of the information industry in the future, according to **Li et al., (2022),** who said such statement. The cloud computing industry is not an exception to the trend of businesses focusing more attention than ever before on streamlined operations, cost reduction, and efficiency development. This is due to the ongoing contraction of the global economy. Does the use of cloud computing ultimately result in an increase in the costs incurred by a firm, or does it justify the cost? The cost, investment, and operation of cloud infrastructure have also become the key to effecting the market competitiveness of corporate cloud businesses in a setting of business homogeneity competition. This is because the cost of doing business has become increasingly homogeneous. The authors have designed a platform called SmartCMP, which offers the value of cloud cost analysis and optimisation, with the intention of resolving these challenges. To begin, from a monetary point of view, a multi-dimensional display and analysis of cloud expenses are carried out in order to identify methods in which costs might be reduced. After that, users will be able to personalise tactics for day-to-day operations,

which will accelerate decision-making and reduce risks. In conclusion, the platform will actively monitor, detect, and rectify potential security issues in real time in compliance with the policies that have been established. Comparing our system to those of our competitors is one way to establish the reliability of our platform.

The author **Theby (2022)** argued that cloud computing evolved into an essential instrument for crisis response for many public sector organisations (PSOs) during the COVID-19 pandemic. This helped to maintain public service delivery and public sector operations during times of unparalleled global turbulence. PSOs were driven to aggressively seek the early adoption of cloud computing as well as the extension of cloud computing capabilities that already existed as a result of the inherent benefits of the technology. These inherent benefits include collaboration, innovation, flexibility, and resilience. In spite of the fact that the rising topic of crisis-driven public sector cloud adoption is important for future crisis response efforts as well as the post-crisis transition to regular public sector operations, academic literature and empirical studies on the subject are scarce, which presents a distinct knowledge gap. This article examines the adoption and expanded use of cloud computing in the public sector in response to a crisis, and it offers recommendations for the progress of research and practise. These recommendations are intended to encourage future research, collaboration, and evidence-based cloud computing deployment and utilisation.

Chidambaram (2022) conducted their research using a methodology known as multiple case study. In the course of the study, they decided to look into three different case projects. One of the considerations that went into selecting the case projects was whether or not the researcher who conducted the study had any involvement in the development or architectural aspects of any of the projects that were reviewed for the research. The existing migration paths to the cloud, best practises, and governance techniques were investigated in order to construct the roadmap. Additionally, an analysis of the current challenges confronted in cloud computing was performed, and data was gathered from a variety of organisations through interviews, questionnaires, and their own publications. The findings of the analysis offered an insight of the existing challenges encountered in cloud optimisation and the implications of those challenges. This understanding, together with an assessment of the best practises that are currently available, led to the development of an original proposal for a governance roadmap for cloud optimisation.

According to **Sannino (2022),** an increasing number of businesses in today's modern day are starting out on a cloud transformation journey or consolidating their position on the cloud in order to take advantage of the scalability, flexibility, and efficiency benefits given by this technology paradigm for their businesses. The consequences that the variable pay-as-you-go cost model, which is commonly adopted by cloud service providers, has on traditional ICT Financial Management processes are frequently disregarded, despite the fact that this model typically has these repercussions. Increased expenditure delegations to business users, who are direct consumers of cloud services, run the danger of diminishing the visibility of the costs created by the Finance department, which in turn challenges the accuracy of spending projections. These challenges, in addition to a number of critical issues caused by the offerings of Cloud Service Providers, such as the extremely granular nature of invoices, constantly changing pricing models, and a lack of standardisation across different provider platforms, present businesses with the necessity of taking steps to ensure that costs associated with the cloud do not exceed the benefits that were promised. This research identifies, through academic research and the collection of empirical evidence, the four main levers on which an organisation needs to act jointly and consistently in order to contain and optimise its Cloud spending. These levers are resources and skills, culture and organisation, processes and policies, and IT tools. In order for an organisation to contain and optimise its Cloud spending, it is necessary for the organisation to act jointly and consistently on all four of these levers. In conclusion, a qualitative model is proposed for assessing the maturity of Cloud Financial Management practises. This model is consistent with the complexity of the Cloud Transformation path that an organisation has chosen to adopt, and it enables organisations to identify any gaps and address them with suitable improvement activities.

Cloud computing is a network-based technology that delivers compute, information, data, and storage services, as stated by Zolkipli and Riduan (2021). The software business is increasingly placing a higher emphasis on Quality Assurance (QA) and Testing criteria in order to facilitate effective product expansion. Presently. Testing is an efficient method for identifying potential vulnerabilities in cloud services and apps before they manifest in the real world. This helps to ensure a high level of safety for these cloud-based resources. As a direct consequence of this, a number of public cloud providers made the announcement that organizations are becoming increasingly enthusiastic about software test automation and Testing Centers of Excellence (COE). This study takes a critical look at cloud protection testing from a number of different angles. Also revealed are voids in recently published

related publications, testing tools, and business transactions involving software test automation. The prospective research implications are highlighted in order to improve both understanding and links between different study topics that are currently being conducted. The paradigm of cloud infrastructure has completely changed the world of computing due to the fact that it offers increased reliability, massive scalability, and lower prices, all of which have attracted both enterprises and individuals. It extends the capabilities of information systems.

3. RESEARCH GAP

According to the previous literatures, ever since the public cloud's rise to prominence, the cloud computing industry has been aggressively promoting hybrid cloud solutions to corporate customers. This is the case since hybrid cloud solutions provide several advantages over public cloud computing. Taking advantage of the fact that not all work will be moved to the public cloud, a number of cloud vendors and system integrators have made the promise to integrate this organization's data centre and the public cloud in a smooth manner. Despite this, the integration of on-premises systems with cloud storage continues to present a substantial difficulty as well as opportunity. The most pressing issues facing businesses today and the most important subjects of conversation may be broken down into two categories: cost optimisation and security. The use of cloud technology confers several benefits to efforts, including reduced operating expenses and accelerated time to market. Therefore, the purpose of this study is to investigate one of the multi-cloud monitor tools that fall under the umbrella of the FinOps concept and to test the features in order to demonstrate whether or not they are advantageous to organisations.

4. RESEARCH QUESTIONS

The research questions followed in this research are as follows:

- What are the benefits and impacts of multi-cloud monitors for enterprises, which assist them to plan and manage the resources they need in the cloud, in terms of efficiency and centralized resource management?
- Is the use of a multi-cloud monitoring tool going to become increasingly popular in the near future as well as essential for businesses?
- What are the advantages of incorporating the ideas of FinOps into the practices of the company?
- How should the capabilities of a company's FinOps be evaluated?

5. OBJECTIVES OF THE STUDY

The objectives of the research are as follows:

- To create and analyse FinOps frameworks to achieve energy and cost efficiency for cloud computing systems.
- To perform a detailed review and concrete knowledge of the practical assessment of real-time FinOps systems.
- To embed sustainability into daily design, development and operational processes in cloud engineering.

6. HYPOTHESIS OF THE STUDY

The hypothesis followed in this research are as follows:

H01: Financial operations (FinOps) will not allow remote teams to make decisions about speed, cost, quality and energy efficiency without being physically present in the data centre.

Ha1: Financial operations (FinOps) allowed remote teams to make decisions about speed, cost, quality and energy efficiency without being physically present in the data centre.

H02: FinOps will not help to achieve financial stability and energy efficiency in cloud computing architecture.

Ha2: FinOps will help to achieve financial stability and energy efficiency in cloud computing architecture.

7. CONCEPTUAL FRAMEWORK

Future market trends include the use of public cloud architectures. Managing costs for a single cloud provider could be easy, but issues occur when using many cloud service providers. In this situation, tools for billing and monitoring that are agnostic start to look intriguing. The best strategy to make the most effective and profitable technological investments for a corporation would be to develop a tool that could be used by all end users in all departments without any technical knowledge. Organizations are introduced to FinOps, a blend of finance and operations.

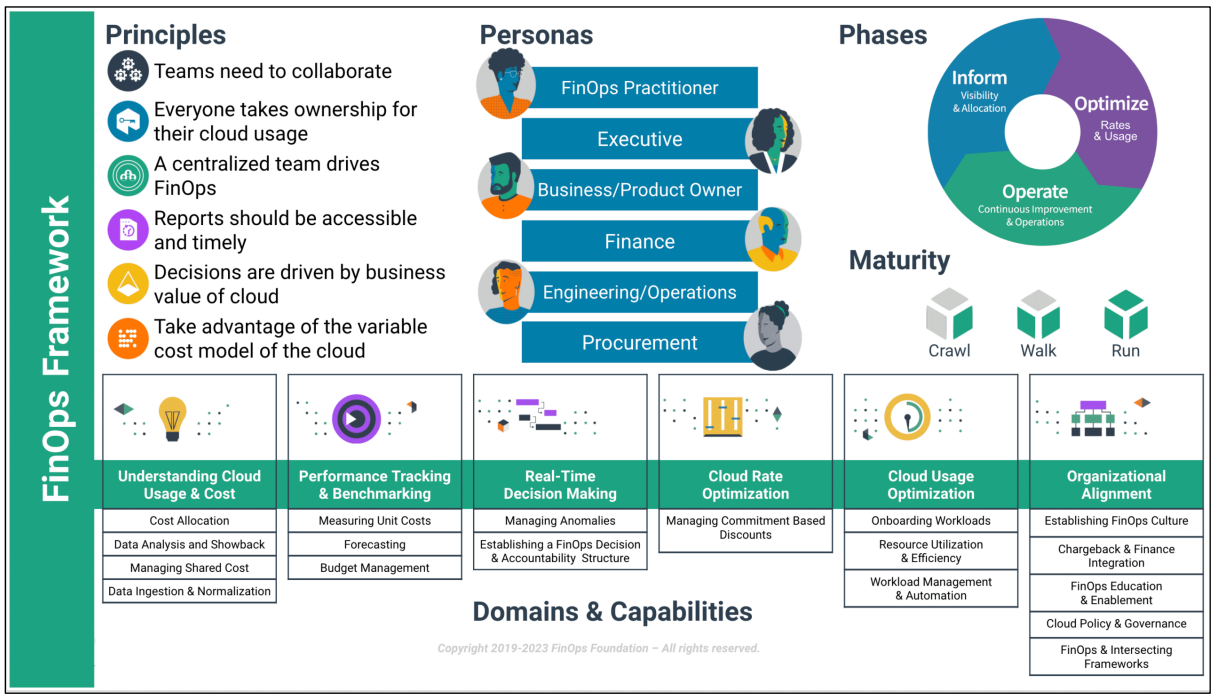

Figure 7.1: A bird's-eye view of the FinOps Framework (Framework overview, 2023)

8. RESEARCH METHODOLOGY

The approach that has been suggested is to carry out a hypothetical evaluation with the purpose of presenting recommendations not only for the management of finances but also for the energy efficiency of several cloud systems. The qualitative analysis approach is going to be utilised as the study method. Researchers that use qualitative methods place an emphasis on the socially constructed nature of reality, the close link that exists between themselves and the subject of their study, and the situational restrictions that mould and direct inquiry. On the other hand, quantitative research places a greater emphasis not on processes but on the measurement and analysis of the causal links between variables. It is expected that inquiries will take place within a value-neutral framework. This research will concentrate on previous works on the subject that were published after 2015 and before 2023. Based on this study, this research will develop cost optimization algorithms that can be used as models to efficiently solve the issue and offer dependable results.

8.1 TOOLS FOR RESEARCH USED:

The primary purpose of this project is to investigate how FinOps practises and cloud monitoring technologies might be linked together to achieve optimal cloud cost management. While still satisfying the requirements of the company, one of the goals is to bring the total cost of cloud computing down. In order to attain this goal, the paper investigates the problems and opportunities presented by recent developments in cloud computing and presents the concepts and principles behind FinOps. It will discuss how the ideas of FinOps and its lifecycle may be implemented in a multi-cloud context, which is one in which organisations employ numerous cloud providers, each of which has their own unique pricing structures, services, and tools. One monitoring tool, notably the IBM multi-cloud (Klarity core) tool, can provide a consolidated perspective of all costs associated with cloud computing while remaining neutral about the cloud service provider.

In a multi-cloud context, where different providers may have variable degrees of performance and reliability, the study will also investigate how to accomplish cost optimisation without compromising performance and reliability without compromising performance and reliability. In addition, the study highlights the critical role that FinOps practises and cloud cost monitoring play in a multi-cloud environment in order to align cloud spending with

business priorities. It also demonstrates how these practises can be leveraged with cloud monitoring tools in order to gain insights into cloud resource usage, recognise opportunities to save money, and ultimately optimise cloud costs.

9. PROBLEM STATEMENT

Customers of Enterprise Cloud services are obligated to investigate the costs associated with the entire lifetime of the cloud service. These costs should include initial migration, operations, and end-of-term ramifications, in addition to licensing implications and operational dangers. It is essential to possess a comprehensive capacity for financial management that is able to deal with multiple clouds. The establishment of a FinOps competence within the company will be of assistance in the management of these issues. A focus should be placed on the FinOps of cloud expenditures in order to reduce the expenses of cloud service by hosting across many clouds. The objective of this research is to devise algorithmic approaches to cost optimization that may be implemented in the form of models for the goal of providing efficient and dependable solutions to the problem at hand. The approach that has been suggested is to carry out a hypothetical evaluation with the purpose of presenting recommendations not only for the management of finances but also for the energy efficiency of several cloud systems. The incorporation of sustainability into the day-to-day design, development, and operational processes of cloud engineering is one way in which the knowledge of FinOps may contribute to the solution of problems associated with cloud computing.

10. DELIMITATIONS

This study will solely concentrate on the collection of knowledge that is largely of a technical and managerial character on the subject of cloud computing, with a particular emphasis placed on the field of financial management.

11. NEED AND SCOPE OF THE STUDY

The rapid growth of cloud computing has presented organizations with numerous opportunities and challenges. As businesses increasingly rely on cloud resources, there is a growing need for effective management strategies to optimize costs, improve efficiency, and ensure sustainability in cloud engineering practices. The need for comprehensive frameworks that address these requirements has led to the emergence of FinOps as a promising approach.

The scope of this study encompasses an empirical evaluation of the FinOps framework for sustainable cloud engineering. It aims to assess the applicability, impact, and effectiveness of FinOps practices in optimizing cloud resource utilization, cost management, and financial efficiency. Additionally, the study examines the role of FinOps in enhancing transparency, accountability, and decision-making related to cloud cost allocation and resource utilization.

The study focuses on evaluating the potential benefits and challenges associated with implementing the FinOps framework. It explores the scope of FinOps practices in addressing sustainability factors such as energy efficiency, carbon footprint reduction, and environmental impact within cloud computing environments.

The findings of this study will provide valuable insights into the effectiveness of the FinOps framework for promoting sustainable cloud engineering practices. These insights will be beneficial for organizations seeking to optimize cloud resource usage, manage costs, and enhance financial control while considering sustainability goals.

By addressing the need for practical guidance and empirical evidence, this study aims to contribute to the existing body of knowledge on FinOps and its implications for sustainable cloud engineering. The scope of the study emphasizes the importance of informed decision-making and strategic implementation of FinOps practices to achieve long-term sustainability and efficiency in cloud computing environments.

12. EXPECTED OUTCOMES OF THE STUDY

This study on the empirical evaluation of the FinOps framework for sustainable cloud engineering is anticipated to yield several outcomes. These outcomes include:

1. Insight into the effectiveness of FinOps: The study is expected to provide empirical evidence regarding the effectiveness of the FinOps framework in optimizing cloud resource utilization, improving cost management, and enhancing financial efficiency. It will contribute to a deeper understanding of how FinOps practices can positively impact sustainable cloud engineering.
2. Identification of sustainability benefits: The study aims to identify and quantify the sustainability benefits associated with implementing the FinOps framework. This includes assessing the impact of FinOps practices on energy efficiency, carbon footprint reduction, and overall environmental sustainability within cloud computing environments.
3. Best practices for FinOps implementation: Through the empirical evaluation, the study will identify and document best practices for implementing the FinOps framework effectively. This will include recommendations for organizations on how to incorporate FinOps practices into their cloud engineering processes to achieve sustainable outcomes.
4. Challenges and mitigation strategies: The study will identify potential challenges and limitations that organizations may face when implementing FinOps practices. It will provide insights into these challenges and offer mitigation strategies to overcome them, ensuring smoother adoption and implementation of the FinOps framework.
5. Decision-making support: By evaluating the impact of FinOps on transparency, accountability, and decision-making related to cloud cost allocation and resource utilization, the study will provide decision-makers with valuable information to make informed choices regarding their cloud investments and operations.
6. Contribution to the research field: The outcomes of this study will contribute to the existing body of knowledge on FinOps and sustainable cloud engineering practices. It will provide a foundation for further research and exploration in this area, fostering ongoing advancements and improvements in the field.

The expected outcomes of this study will provide practical insights, empirical evidence, and recommendations that can guide organizations in adopting and implementing the FinOps framework for sustainable cloud engineering. The study's findings will contribute to informed decision-making, cost optimization, and improved sustainability in cloud computing environments.

13. SCOPE AND SIGNIFICANCE OF THE STUDY

In this day and age of information technology, cloud computing is swiftly becoming the standard rather than the exception. The practice of businesses owning data centers has given way to the adoption of the more modern practice of receiving virtualized computing capabilities as a service. This method allows additional flexibility while also reducing associated costs. It is getting more expensive to maintain computational resources than it is to obtain them. Companies such as Google, Microsoft, Amazon, and others like them provide these kinds of services on a worldwide scale and offer a wide choice of provisioning options for their customers. Traditional models of technology consumption and acquisition have been put to the test as a result of the widespread adoption of cloud computing. To formulate an expansive and innovative plan for making the most of the benefits offered by the cloud, it is essential to have a solid understanding of the actual expenses associated with the various cloud-based solutions that are currently available.

The scope of this study, "Empirical Evaluation of FinOps Framework for Sustainable Cloud Engineering," is to assess the effectiveness of the FinOps framework in promoting sustainable practices within cloud computing environments. It aims to analyze the financial operations and energy efficiency aspects of cloud systems to provide efficient and reliable solutions. The study will explore the following areas:

1. Evaluation of FinOps Framework: The study will assess the applicability and effectiveness of the FinOps framework in optimizing cloud resource utilization, reducing costs, and enhancing financial management. It will investigate how FinOps practices can contribute to sustainable cloud engineering.
2. Financial Management and Cost Optimization: The study will focus on understanding the financial implications associated with various cloud-based solutions. It aims to develop algorithmic approaches and models for cost optimization, considering factors such as migration, operations, licensing, and long-term ramifications. The research will provide recommendations for effective financial management and reduction of cloud service expenses.
3. Energy Efficiency and Sustainability: The study will incorporate sustainability into the design, development, and operational processes of cloud engineering. It will explore how the integration of FinOps knowledge can contribute to energy-efficient cloud systems. The research will aim to present recommendations for enhancing energy efficiency and reducing the environmental impact of cloud computing.

The significance of this study lies in its contribution to the field of cloud engineering and sustainability. It will provide empirical evidence and practical insights into the effectiveness of the FinOps framework in promoting sustainable practices. The study's findings can guide organizations in adopting FinOps practices to optimize costs, improve financial management, and enhance energy efficiency in cloud computing environments.

Furthermore, this research addresses the emerging challenges and opportunities in cloud computing, which have become the standard practice for businesses. The study highlights the need for comprehensive financial management and capacity to deal with multiple clouds, promoting a holistic approach to cloud expenditure management.

This study aims to bridge the gap between FinOps, energy efficiency, and sustainability within cloud engineering. It will contribute to knowledge by providing recommendations, models, and insights for organizations seeking to achieve cost optimization, financial sustainability, and environmental responsibility in their cloud-based operations.

The incorporation of sustainability into the day-to-day design, development, and operational processes of cloud engineering is one way in which the knowledge of FinOps may contribute to the solution of problems associated with cloud computing.

14. CHAPTERIZATION

Five chapters will be used to present this thesis.

CHAPTER 1: INTRODUCTION – This chapter will provide a summary of multiple cloud management technologies, the state of cloud computing monitoring, theoretical background of public cloud computing, new concept of FinOps and multi cloud strategy as well as the thesis's goals and research topics.

CHAPTER 2: LITERATURE REVIEW – This chapter provides a thorough summary of previous works on this subject.

CHAPTER 3: RESEARCH METHODOLOGY - This chapter will illustrate monitoring tools and services by establishing various applications and resources in the public cloud and continuing to monitor the cost and consumption of those resources and applications.

CHAPTER 4: RESULTS AND ANALYSIS – This chapter will include will look more closely at Klarity's core features, including how to set up an account, test them, and generate various reports.

CHAPTER 5: CONCLUSION AND FUTURE RECOMMENDATIONS: The final chapter of the thesis is devoted to discussion and conclusion.

BIBLIOGRAPHY

1) Cheng, M., Li, J., & Nazarian, S. (2018, January). DRL-cloud: Deep reinforcement learning-based resource provisioning and task scheduling for cloud service providers. In *2018 23rd Asia and South pacific design automation conference (ASP-DAC)* (pp. 129-134). IEEE.

2) Chidambaram, R. (2022). Roadmap for Cloud Optimization.

3) Duan, Q. (2017). Cloud service performance evaluation: status, challenges, and opportunities–a survey from the system modeling perspective. *Digital Communications and Networks*, *3*(2), 101-111.

4) FinOps Foundation, November 2021. What is FinOps? FinOps Foundation Blog. URL:

5) Framework overview. (2023). Retrieved April 22, 2023, from Finops.org website: https://www.finops.org/framework/

6) Halabi, T., & Bellaiche, M. (2017). Towards quantification and evaluation of security of Cloud Service Providers. *Journal of Information Security and Applications*, *33*, 55-65.

7) Li, F., Wu, G., Lu, J., Jin, M., An, H., & Lin, J. (2022, October). SmartCMP: A Cloud Cost Optimization Governance Practice of Smart Cloud Management Platform. In *2022 IEEE 7th International Conference on Smart Cloud (SmartCloud)* (pp. 171-176). IEEE.

8) Mei, L. (2023). Cost Optimization in cloud costs with FinOps and multi-cloud billing monitoring tool.

9) Odun-Ayo, I., Ananya, M., Agono, F., & Goddy-Worlu, R. (2018, July). Cloud computing architecture: A critical analysis. In *2018 18th international conference on computational science and applications (ICCSA)* (pp. 1-7). IEEE.

10) Rashid, A., & Chaturvedi, A. (2019). Cloud computing characteristics and services: a brief review. *International Journal of Computer Sciences and Engineering*, *7*(2), 421-426.

11) Sannino, R. (2022). The impact of cloud adoption on ICT financial management: how to address emerging challenges.

12) Subramanian, N., & Jeyaraj, A. (2018). Recent security challenges in cloud computing. *Computers & Electrical Engineering*, *71*, 28-42.

13) Theby, M. (2022). Public Sector Cloud Computing Adoption and Utilization during COVID-19: An Agenda for Research and Practice. *International Journal of Managing Public Sector Information and Communication Technologies (IJMPICT)*, *13*(1).

14) Zolkipli, M. F., & Riduan, A. I. (2021). Cloud computing and security challenge. *Journal of Applied Technology and Innovation (e-ISSN: 2600-7304)*, *5*(3), 38.