ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE

SCHOOL OF INFORMATION SCIENCE

A CLOUD COMPUTING DEPLOYMENT MODEL FOR ETHIO TELECOM

By: Almehadi Ali Dekebo

July ,2020

Addis Ababa, Ethiopia

ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE

SCHOOL OF INFORMATION SCIENCE

A CLOUD COMPUTING DEPLOYMENT MODEL FOR ETHIO TELECOM

A Thesis Submitted to School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Information Science and System

(*Information System Specialization*)

By: Almehadi Ali Dekebo

Advisor: Lemma Lessa (Ph.D.)

July,2020

Addis Ababa, Ethiopia

ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE

SCHOOL OF INFORMATION SCIENCE

A CLOUD COMPUTING DEPLOYMENT MODEL FOR ETHIO TELECOM

By: Almehadi Ali Dekebo

Name and signature of Members of the Examining Board

Lemma Lessa (Ph.D.) Advisor	_____ Signature	_____ Date
Million Meshesha (Ph.D.) Examiner	_____ Signature	_____ Date
Temtim Assefa (Ph.D.) Examiner	_____ Signature	_____ Date

Dedicated To

To all Oromo martyrs who have sacrifices their lives struggling for our nation. Especially to Qeerroo and Qarres, and Hachalu Hundesa.

Declaration

This thesis has not previously been accepted for any degree and is not being concurrently submitted in candidature for any degree in any university.

I declare that this thesis entitled “A Cloud Computing deployment model for Ethio Telecom” is a result of my own investigation, except where otherwise stated. I have undertaken the study independently with the guidance and support of my research advisor. Other sources are acknowledged by citations giving explicit references. A list of references is appended.

Signature: _____

Almehadi Ali Dekebo

This thesis has been submitted for examination with my approval as university advisor.

Advisor’s Signature: _____

Lemma Lessa (Ph.D.)

Acknowledgements

“And remember when your Lord proclaimed, 'If you are grateful, I will surely increase you in favor; but if you deny, indeed, my punishment is severe**”** (Quran 14:7)

First and foremost, I would like to say Alhamdulillahi rabbil Alamin. All the praises and thanks be to Allah (s.w.t) who is the Lord of the universe.

I would like to express my sincere gratitude to my advisor Dr. Lemma Lessa for the continuous support of my thesis, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my thesis.

My deepest appreciation goes to my family member. To my father Ali Dhekebo ,my mother Medina Derarso and my brothers Abdulmehadi and Abdulhamid for their moral and psychological support throughout my study. Without your Du’a and support this would not have been possible.

My special thanks to all research participants of Ethio telecom especially information system division who have given me time from their busy schedule. To my supervisor Petros Tesfaye for his kind cooperation and assistance during my study.

Almehadi Ali
July 2020
Addis Ababa, Ethiopia

Abstract

Adoption of cloud computing can reshape the organization IT landscape and can heavily impact its business strategy and performance. To ensure successful adoption of cloud computing and to properly manage changes that occur because of cloud computing, an organization needs to identify what kind of cloud computing deployment model fits the organization needs and what must be fulfilled before adopting the potential deployment model. This is because each cloud deployment model satisfies different organizational needs and needs different readiness levels of the organizations. The general objective of this research is to propose a cloud computing deployment model that aligns with the specific need of Ethio telecom and to assess the readiness level of Ethio telecom to adopt the potential deployment model.

Both qualitative and quantitative research approach were used. Data were collected via questionnaire survey, document analysis, and interviews. A document analysis conducted to understand Ethio telecom infrastructure and service which includes understanding basic service, business and mission critical systems and customers while interview to assess challenges of current infrastructure. The analysis of the interviews showed that, DC management issues, storage issues, outdated technology, lack of resource utilization, reduced agility and security threat are the main challenges of current infrastructure. The study indicated that Private Cloud deployment model has both the ability of cloud model to fulfill a business needs and the level of cloud model to meet the factors to select a cloud deployment model.

A questionnaire was used for conducting a readiness assessment of ethiotelecom to adopt the proposed model in three major phases using Gartner Magic Quadrant. Overall result of the assessment shows that. core business/competitive position are barrier to 6 IT service and application, standardization are barrier to 4 IT service and application ,compliance are barrier to 4 IT service and application, Service type are barrier to 4 IT Service and application, and importance or availability are barrier to 3 IT Service and application. On the other hand, degree of distribution, network connectivity, and identity management are enabler for Ethio telecom to adopt the proposed model. Based on the finding and consideration to most critical factors, 10 IT service and application have been categorized as likely cloud ready. This study takes Ethio telecom as a cloud user, the finding of this study cannot be generalized to other telecom service provider who use and provide a cloud service.

Keywords: Cloud Computing adoption, Cloud Computing Readiness , Cloud Deployment Model

Table of Contents

Declaration ii
Acknowledgements iii
Abstract iv
List of Figures ix
List of Tables x
List of Acronyms xi
CHAPTER ONE 1
INTRODUCTION 1
1.1. Background 1
1.2. Statement of the problem 2
1.3.1. Research Question 5
1.3. Objective of the study 5
1.4.1. General objective 5
1.4.2. Specific objective 5
1.4. Significance of the study 6
1.5. Scope of the study 6
1.6. Organization of the Thesis 6
1.7. Chapter Summary 7
CHAPTER TWO 8
LITERATURE REVIEW 8
2.1. Overview 8
2.2. Cloud Computing Definitions 8
2.3. Characteristic of Cloud Computing 10
2.4. Enabling Technologies of Cloud Computing 11
2.5. Cloud Computing Architecture 13
2.6. Cloud Computing Service Model 14
2.6.1. Software as a Service (SaaS) 14
2.6.2. Platform as a Service (PaaS) 15
2.6.3. Infrastructure as a Service (IaaS) 16
2.6.4. Other Service Model 16
2.7. Cloud Computing Deployment Model 18
2.7.1. Public cloud model 18

2.7.2. Private cloud model 19
2.7.3. Community cloud model 20
2.7.4. Hybrid cloud model 21
2.8. Drivers of Cloud Computing 22
2.9. Challenges with Cloud Computing 25
2.10. Cloud Computing in Telecommunications Sectors 27
2.10.1. Role of cloud computing in telecom operator 28
2.10.2. Benefit of Cloud Computing in telecom 31
2.10.3. Telecoms Concerns in the Cloud 32
2.11. Cloud Deployment Model Selection Criteria 32
2.12. Related work 37
2.13. Chapter Summary 42
CHAPTER THREE 44
RESEARCH DESIGN AND METHODOLOGY 44
3.1 Overview 44
3.2 Research Design 44
3.2.1. Research Process 44
3.2.2. Research approach 45
3.2.3. Research Strategy 46
3.2.4. Sampling Design and Sampling Techniques 47
3.3 Research Techniques 48
3.3.1 Data collection 49
3.3.2 Data Analysis Technique 50
3.3.3 Pilot Testing 51
3.3.4 Validity and Reliability 51
3.4 Readiness Assessment Method 52
3.5 Chapter Summary 54
CHAPTER FOUR 55
ETHIO TELECOM CLOUD DEPLOYMENT MODEL 55
4.1 Overview 55
4.2 Data collection 55
4.3 Ethio telecom Infrastructure and Services 56

4.3.1. Basic service 56
4.3.2. Business and mission critical systems 59
4.3.3. Ethio telecom Datacenter 61
4.3.4. Ethio telecom Customers 62
4.3.5. Challenges of current Infrastructures 62
4.5 Evaluation of Cloud Deployment Alternatives 64
4.5.1. Public cloud 65
4.5.2. Private cloud 66
4.5.3. Hybrid cloud 67
4.6 Cloud Deployment Model Selection 69
4.7 Proposed Deployment Model 71
4.8 Discussion 76
4.9 Chapter summary 77
CHAPTER FIVE 78
ETHIO TELECOM READINESS ASSESSMENT 78
5.1 Overview 78
5.2 Readiness Assessment 78
5.3 Readiness Assessment Result 78
5.3.1. Identification of IT Service and applications 78
5.3.2. IT services and applications 80
5.3.3. Cloud readiness assessment criteria 82
5.3.4. Screening of IT Service and applications 84
5.3.5. Categorization of IT Service and applications 89
5.4 Ethio telecom Cloud deployment model 90
5.5 Discussions 94
5.6 Chapter Summary 96
CHAPTER SIX 98
CONCLUSION AND RECOMMENDATION 98
6.1 Conclusion 98
6.2 Recommendation 99
6.3 Research contribution and implications 100
6.4 Limitation of the study 100

6.5 Future work 101
REFERENCE 102
Appendix A: Interview question for Model Inputs 114
Appendix B : Expert's Model Evaluation form 115
Appendix C : Survey for Identifying Application and service 118
Appendix D : Survey for Cloud readiness Assessment 120
Appendix E : A Magic Matrix evaluation for criterion 128
Appendix F : A Magic Matrix evaluation for IT Service and Application 131

List of Figures

Figure 2.1. Cloud Computing definition schema (Mell & Grance, 2011) 10
Figure 2.2. Cloud Computing Architecture Adopted from (Zhang et al., 2010).....13
Figure 2.3. Telecom operators three roles as cloud service provider (Ericson, 2012).....29
Figure 2.4. Telecom Operator as Cloud user (Ericson, 2012). 30
Figure 2.5. Telecom Operator as Cloud User and Service Provider (Ericson, 2012).....31
Figure 2.6 Gartner Magic Quadrants (Gartner ,n.d) 53
Figure 3.1. The Research steps 45
Figure 3. 2 Questioner sample size 48
Figure 4.1. Three-tier Data Center Architecture (Kliazovich *et al.* 2012).....61
Figure 4.2. Proposed cloud deployment model 72
Figure 4. 3 Components of proposed cloud deployment model.....75
Figure 5.1 Participants' role in the organization.....79
Figure 5.2 The participants' experience profile.....80
Figure 5.3 The participants' experience profile.....80
Figure 5.4 Frequency of IT application and service 81
Figure 5.5 Participants role in the organization for screening.....85
Figure 5.6 The participants experience profile for screening.....86
Figure 5.7 Updated proposed cloud deployment model 91
Figure 5.8 Updated components of proposed cloud deployment model.....92

List of Tables

Table 2.1. Cloud Computing Service Model Comparison adopted from (Fawaz, 2017) 18
Table 2.2. Cloud Computing Deployment Models Comparison adopted from.....22
Table 2. 3 Cloud computing deployment model comparison criteria.....37
Table 2.4. Summary of Related Works.....42
Table 4.5. Comparison of the cloud deployment models.....69
Table 5.1 IT Service and application identified for Cloud readiness assessment 82
Table 5.2 IT service and application categorized as likely cloud ready 90

List of Acronyms

AHP	Analytic hierarchy process
APN	Access Point Name
BSS	Business Support Systems
CaaS	communication as a service
CapEx	Capital Expenses
CBS	Converged Billing System
CDMA	Code-division multiple access
CRBT	Caller ring back tone
CRM	Customers relation Management
DaaS	Desktop as a Service
DbaaS	Database as a Service
EC2	Elastic Compute cloud
Ecaf	Electronic Customer accusation form
ETC	Ethiopian Telecommunications Corporation
EVDO	Evolution-Data Optimized
FL_NGN	Fixed Line – Next Generation Network
FWT	Fixed wireless terminal
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
GTP	Growth and Transformation Plan
IaaS	Infrastructure as a service
IDC	Internet Data center
IPCC	Internet Protocol Contact Center
ISDN	Integrated services digital network
MMSC	Multimedia Messaging Service Center
MPLS	Multi-Protocol Labeled Switch
MTN	Maritime Telecommunications Network,
MVAS	Mobile value-added services (MVASs
NaaS	Network as a service

NGFW	Next-generation Firewall (NGFW)
NIST	National Institute of Standards and Technology
OpEx	Operating Expenses
OSS	Operations Support System
PaaS	Platform as a service
PSTN	Public switched telephone network
REST	Representational State Transfer
S3	Simple Storage Service
SaaS	Software as a service
SLA	Service Level Agreement
SMS	Short message service
SMSC	Shor message service center
SOAP	Simple Object Access Protocol
TaaS	Testing as a Service
TCO	Total Cost Ownership
USSD	Unstructured Supplementary Service Data
VAS	Value Added Service
VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal
WCDMA	Wideband Code Division Multiple Access

CHAPTER ONE

INTRODUCTION

1.1. Background

Cloud computing (CC) represents a paradigm shift in the way information technology resources and services are delivered (Sabi et al., 2016). Cloud Computing is defined by the US National Institute of Standards and Technology (NIST) as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell & Grance, 2011). Cloud computing is especially attractive to organizations due to its many advantages which include the high-performance capabilities it offers, its low entry costs, universal access, flexibility, availability, and scalability (Zhang et al., 2010).

The effectiveness of cloud computing is being limited by many challenges and concerns that affect both firms and cloud providers (Seifu et al., 2017). Adopting cloud computing changes not only the technology used by an enterprise but also how business operations are managed (Raj & Periasamy, 2011). Besides, switching enterprise resources to a cloud involves decision making at the strategic and operational levels and could potentially impact all aspects of the firm (Andrikopoulos, 2014). However, with the advantages offered by cloud computing, both strategically and operationally, there is still a relatively slow adoption rate. Slow adoption of cloud computing may be because of some of the potential pitfalls of the technology such as security concerns, failure downtime resulting from server maintenance or unforeseen outages, implementation complexity and compatibility issues (Low, 2011). Data lock-in and data ownership related issues are concerns that firms face during cloud adoption (Alvarez, 2011).

The migration of IT services to the cloud can reshape the enterprise's IT landscape and can heavily impact its business strategy and performance (Birhane, 2018). Switching the service to a wrong cloud model can also result in low performance. Since there are several cloud computing deployment models that firms can adopt and each model architecture offers different advantages and constraints, many firms find it as a great decision challenge to identify the right model that will optimally address their business needs (Birhane, 2018). Hence, selecting the wrong cloud

deployment model for cloud service can be operationally costly and potentially could harm a business strategy. Besides the potential risks and the decision concerns, there is little guidance available from industries and scholars on how to adopt this technology from the firms' context (Ferguson-Boucher & Convery, 2011).

Currently, cloud service providers are offering a wide range of cloud-based ICT solutions. However, the acceptance and usage of these services in Ethiopia are slow and discouraging. To ensure successful adoption of cloud computing and to properly manage changes that occur because of cloud computing, an organization needs to identify what kind of cloud computing deployment model fits the organization's needs and what must be fulfilled before adopting the potential deployment model (Rountree & Castrillo, 2013).

This research will provide a comprehensive understanding and investigation into Cloud Computing phenomena in Ethio telecom to develop a cloud computing deployment model that will fit the Ethio telecom's need and to assess readiness level of the organizations to adopt the proposed deployment model. The deployment model can assist Ethio telecom to identify what potential cloud computing models are suitable with Ethio telecom needs and helps Ethio telecom for measuring how prepared the organization is for the move to Cloud Computing implementation and identifying organizational strengths that can be used to support Cloud Computing initiatives.

1.2. Statement of the problem

The advancement of innovative technologies from time to time has changed the way organizations handle their business processes and the need to adopt these technologies is becoming critical for business organizations to be competitive in the market (Selamawit, 2014). Nowadays, due to its numerous advantages and benefits, several organizations are adopting and consuming cloud services. However, their adoption of cloud computing has concerns (Aschalew, 2018). The physical location of cloud providers is overlooked by the studies (Alkhater, 2014), it can be an important determinant of the cloud adoption process in the context of the firms in developing countries like Ethiopia where most of the cloud providers are over the sea. The risk of moving highly confidential financial services and sensitive data to the public cloud can be enormous if not properly controlled. Storing data in locations within different jurisdictions could cause problems for firms and raises questions regarding data sovereignty and jurisdiction over the stored data (Alkhater, 2014; Marston et al., 2011). In other studies cloud computing, as a concept, is still

relatively new and misunderstood. They add that this presents several research challenges that require solving before the understanding of cloud computing improves (Ali Babar & Chauhan, 2011).

There are a few pieces of research conducted on cloud computing areas on specifically on Telecommunication sectors. Ramzan et al. (2018) Conducted a study to identify factors and issues addressed while implementing and deploying cloud computing in telecommunication sectors. Empirical qualitative and quantitative research methodology is used to identify the obstacles faced for implementing and deploying CC in various telecom industries. The study identified that the two most important barriers for using CC are security issues and transferring data to a third party. while unawareness of the managers on how to calculate the results produced by CC, benefit of cost by using CC, quality, availability of services, and requirements for data protection are also barrier for using CC in telecom sectors.

Satheesh & Rao (2016), conducted a study with objective to improve the end-to-end performances of cloud mobile media delivered through mobile cloud computing systems by studying operation of cloud computing and wireless networks in mobile computing environments. They were studied the issues that arise when jointly using the operations of cloud and wireless networks in mobile cloud computing environments with the telecom operator cloud. They proposed a homogeneous Bertrand system model to simulate CMM SPs and HWNs with small cells. The simulation results show that the dynamics of cloud operations have a significant impact on the heterogeneous wireless network, and joint optimization is necessary for the operations of cloud and wireless networks. By jointly optimizing the operations of clouds and wireless networks, the proposed scheme can significantly improve the performance of the mobile cloud computing systems.

Zhou et. al, (2010) also Proposed a Service Storm, a novel self-service telecommunication Service Delivery Platform with Platforms- a-Service technologies to support rapid and flexible construction and delivery of value-added services in the cloud environment as an open developer community. The proposed model includes a rapid assembly model and tools for codeless and off-premise integration of telecom services and application logic based on Web 2.0 technologies, Cloud based resource isolation, management, capacity planning and scaling for dynamic topology deployment and elastic infrastructure support, and Automatic deployment and monitoring in

runtime. The model is also tested with SMS and Web based mobile how these technologies and architectures enable the new business model for telecommunication operator. The finding shows that Service Storm has provided more flexibility and conveniences to the individual and organization users and helped them save invest and cost. With the increasing amount of the end users the telecommunication operator and business partner of Service Storm can win more profit and significantly enhance the diversity of value-added services with lower cost and shorter time to market. The study is also recommends enhancing the elements of service assembler and the security of the deployed solution environments.

To my knowledge, three investigations have been conducted on cloud computing. A study was conducted to assess the readiness level of Ethio Telecom to implement cloud computing services using the STOPE model. The study shows that Strategy has a strong relationship with Technology, Organization, People, and Environment. The lack of Readiness to implement cloud computing affects all domains especially organizations and people readiness to adopt cloud computing (Ruth,2017). The researcher recommends using a different framework to assess readiness level if any improvements could be observed. The study did not identify whether Ethio telecom is eager to adopt cloud computing, what potential deployment model is best fit Ethio telecom needs, and factors affecting the adoption of the potential deployment model.

Ethio telecoms newly implemented Desktop cloud computing infrastructures analyzed and assessed the impact and technical advantage they brought to the organization. The study shows that desktop cloud computing brought a positive impact on call center's service quality and work environment. The study recommends future works on developing a virtualized network for the desktop cloud system of call center (Lily, 2017). This research shows us that Ethio telecom has a willingness to adopt cloud computing but the level of readiness to adopt cloud computing is not clear and what factors affecting the adoption of the potential computing model is not studied.

In other studies, a carrier-based cloud service architecture proposed by taking the client's profile and requirement as a context (Aschalew, 2018). The focus of this study is to assess what kind of cloud service (IaaS, PaaS, and SaaS) Ethio telecom gives to its clients. The study did not identify what potential deployment model is best fit Ethio telecom needs and factors affecting the adoption of the potential deployment model.

From the above studies, we can see that there is a gap in what kind of cloud computing deployment model best fit Ethio telecom needs and the readiness level of the telecom to adopt the potential deployment model. This is because each cloud deployment model satisfies different organizational needs and needs different readiness levels of the organizations. Each cloud deployment model has a different value proposition and different costs associated with it (Rountree & Castrillo, 2013).

Therefore, it is the right time and worth to study what kind of cloud computing deployment model best fit Ethio telecom and need to identify the readiness level of Ethio telecom to adopt the potential deployment model.

1.3.1. Research Question

Accordingly, this research attempts to answer the following main research questions.

- What are Ethio telecom's cloud computing deployment model needs?
- How can a customized cloud computing deployment model be proposed to guide cloud computing implementation at the company?

1.3. Objective of the study

1.4.1. General objective

The general objective of this research is to propose a cloud computing deployment model that aligns with the specific need of Ethio telecom and to assess the readiness level of Ethio telecom to adopt the potential deployment model.

1.4.2. Specific objective

The specific objective of the study is to:

- ✓ Review cloud computing-related pieces of literature to understand various cloud services, deployment models.
- ✓ Identify Ethio Telecom's cloud computing needs.
- ✓ Propose a cloud computing deployment model that aligns with the specific need of Ethio telecom.
- ✓ Assess the readiness level of Ethio telecom to adopt the potential deployment model.
- ✓ Present recommendations to fill identified gaps.

1.4. Significance of the study

The outcomes and results of this research will have potential value to the organization and the research community. For the organization, the proposed model will enable an organization to identify the right cloud deployment model for their business needs, the current status of the organization to adopt cloud computing, and helps to understand the barriers and enablers of cloud computing readiness. The research community will benefit from this research because it will contribute to the existing body of knowledge, especially in cloud computing deployment models in telecom sectors, specifically in Ethiopia. Additionally, the study could be used as a reference for further studies to be considered in different governmental and non-governmental organizations of Ethiopia. Furthermore, it helps cloud vendors by providing them country and sector-specific factors that they need to consider adjusting their services and rethink their marketing strategies.

1.5. Scope of the study

The main goal of this study is to propose a cloud computing deployment model that aligns with the specific needs of Ethio telecom and to assess the readiness level of Ethio telecom to adopt the potential cloud deployment model. Telecom operators align themselves in cloud value chain as cloud service providers, cloud service users and both as users and providers but the proposed deployment model in this study takes Ethio telecom as a cloud user. This study does not consider the development of cloud service implementation prototype.

1.6. Organization of the Thesis

The thesis is organized in five chapters, the first chapter which is the introductory part gives highlights about the paper. The remaining chapters of this thesis are organized as follows, chapter two focuses on the literature review of cloud computing. Chapter three discusses the research design and methodology that is used, it describes the data collection method, sampling size and methods, and the data interpretation and validation. Chapter four will discuss cloud deployment model for Ethio telecom. Chapter five will discuss the readiness level of Ethio telecom to adopt the potential deployment model and provides the analysis of the results and its findings. Chapter six summaries the research, provide conclusions, and discusses further areas of research and recommendations.

1.7. Chapter Summary

This chapter has introduced the thesis by presenting the background of the research and the motivations for conducting this research. This was followed by stating the objectives of the research and the contribution to the knowledge it offers and ethical considerations. Finally, the chapter presented an outline of the thesis and a summary of each chapter.

CHAPTER TWO

LITERATURE REVIEW

2.1. Overview

This chapter provides a literature review of Cloud Computing to provide a technical basis for the study's investigation. This chapter starts by exploring a definition of Cloud Computing and its main characteristics are discussed besides enabling technologies that help in understanding the Cloud Computing phenomenon. Investigation of different CC service models and deployment models is conducted and the benefits and concerns of each are discussed, followed by a comparison. Additionally, the advantages that drive Cloud Computing adoption and the concerns that may affect adoption are identified. The role of Cloud computing in telecommunication sectors is also presented. Finally, different cloud computing adoption framework related studies are reviewed.

2.2. Cloud Computing Definitions

A unique characteristic of Cloud computing is that it is based on a pay per use model which allows companies to pay for services on demand (Misra & Mondal, 2011). Several researchers and practitioners have attempted to define cloud computing in different ways (Lensa,2017). Although there is no generally accepted definition of Cloud Computing (Asatiani et al., 2014; Marston et al., 2011), there are some well-recognized definitions for it. The National Institute of Standards and Technology (NIST) at the US Department of Commerce has defined Cloud Computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell & Grance, 2011). The NIST definition considers only the technological perspective, overlooking an important aspect of Cloud Computing, which is the business side.

Vaquero et al. (2008, p.51) offered a definition for Cloud Computing that encompasses all cloud features, defining it as "*a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically re-configured to adjust to a variable load (scale), allowing also for an optimum resource utilization.*

This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the infrastructure provider by means of customized SLAs".

Klems, et al., (2009), defines cloud computing as, "building on compute and storage virtualization technologies, and leveraging the modern web, Cloud Computing provides scalable and affordable compute utilities as on-demand services with variable pricing schemes, enabling a new consumer mass market. It provides a service where consumers can rent (virtualized) infrastructure as needed, deploy applications and store data on the infrastructure and access the applications and data via web protocols on a pay-per-use basis".

Marston et al. (2011, p.177) outlined a more comprehensive definition for Cloud Computing, which is as follows: "an information technology service model where computing services (both hardware and software) are delivered on-demand to customers over a network in a self-service fashion, independent of device and location. The resources required to provide the requisite quality of service levels are shared, dynamically scalable, rapidly provisioned, virtualized, and released with minimal service provider interaction. Users pay for the service as an operating expense without incurring any significant initial capital expenditure, with the cloud services employing a metering system that divides the computing resource in-appropriate blocks".

By analyzing the above four definitions of Cloud Computing (Mell & Grance, 2011; Marston et al., 2011; Klems, et al., (2009); Vaquero et al., 2008), they emphasize a similar aspect. Firstly, Cloud Computing is a model for delivering IT services and resources, not just new technology. Secondly, the provisioning of the computing resources is automatic and with a minimum of human interaction. Thirdly, access to a large pool of resources is over a network. Fourthly, IT services and resources are also available on-demand with dynamic scalability and elasticity. Additionally, the provisioning of IT resources should be independent of device and location (i.e., should have the characteristic of ubiquity). Figure 2.1 shows a Cloud Computing definition schema based on the National Institute of Standards and Technology's (NIST) definition (Mell & Grance, 2011).

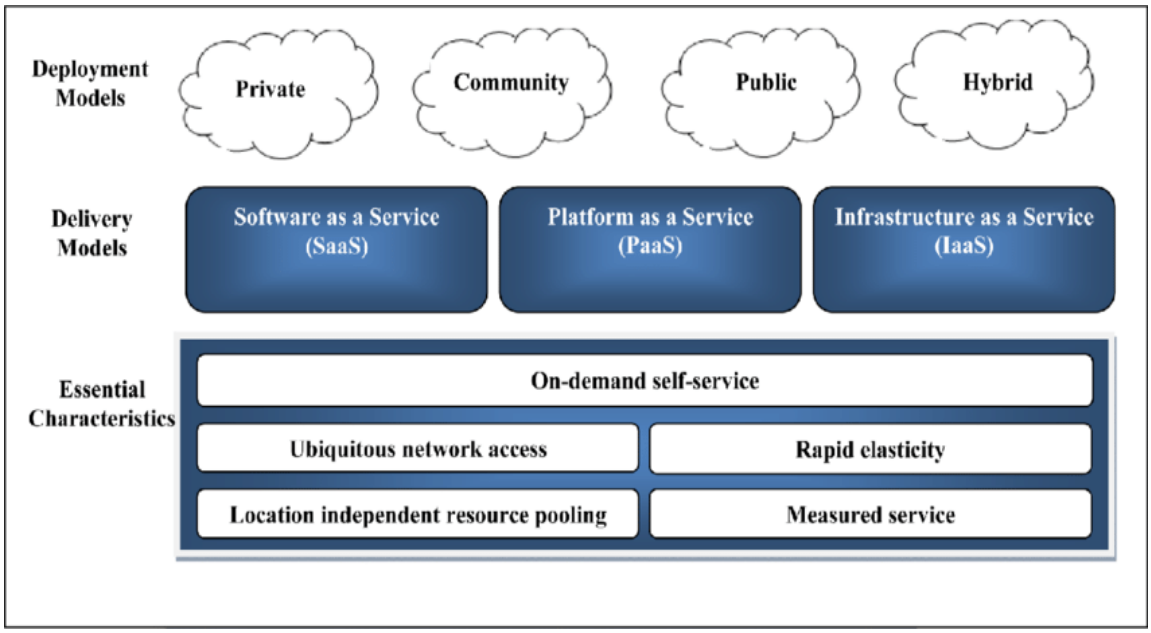


Figure 2.1. Cloud Computing definition schema (Mell & Grance, 2011)

2.3. Characteristic of Cloud Computing

Based on the previous analysis and The National Institute of Standards and Technology (NIST) definition outline, the defining characteristics of Cloud Computing are identified as follows:

- **On-demand self-service:** consumers can unilaterally provision computing capabilities according to their demand whenever they need, and can obtain computing capabilities, such as software, storage, or CPU time automatically (Mell & Grance, 2011).
- **Broad network access:** Computing resources are made available via a network, either the organization's network or the Internet, and are accessible from various locations (Mell & Grance, 2011; Marston et al., 2011). The ubiquitous nature of these resources allows them to be independent for end-user devices, so the user can acquire the services by using different devices such as workstations, smartphones, tablets, etc. (Marston et al., 2011).
- **Resource pooling:** Computing resources provided by a service provider are pooled and shared by many consumers without having any control or knowledge of the exact management of the resources (Calabrese & Cannataro, 2015). The resources are either physical or virtual resources and are assigned and reassigned dynamically based on consumer demand (Mell & Grance, 2011). The geographical locations of the resources

should be hidden from the user. Nevertheless, the user can query to limit the domain location of the physical resources being used to meet the legal constraints (Mousavi, 2013).

- **Rapid elasticity:** Computing capabilities are elastically provisioned and released up or down based on customer demands (Mell & Grance, 2011). This characteristic enables the services to be expanded and contracted to serve the actual need. This automated process ensures that the service is instantly provided if the demand rises and released if the demand drops and therefore, increasing efficiency while providing transparency to end-users (Mousavi, 2013).
- **Measured service:** The services used are measured by metering capabilities and parameters such as storage, processing, and bandwidth to determine the actual usage (Calabrese & Cannataro, 2015). The measured usage can be used for charging or for controlling the allocation of the resources (Mell & Grance, 2011).

2.4. Enabling Technologies of Cloud Computing

Cloud Computing is not a stand-alone phenomenon in the IT industry, and consequently, some primary technologies need to be explained to support the understanding of Cloud Computing. This section explains the enabling technologies of Cloud Computing.

- Virtualization is a key technology that has inspired many Cloud Computing characteristics and mechanisms (Sajid & Raza, 2013). Virtualization means converting one physical IT resource to multiple logical IT resources (Sultan & van de Bunt-Kokhuis, 2012). Most types of IT resources can be virtualized including server, storage (virtual disk), network, and power (Berhane, 2018). It acts as a mask that hides the physical characteristics of computing resources to enhance the simplicity of other systems, applications, or end-users interacting with those resources (Erl et al., 2013). This technology provides many benefits, such as cost-effectiveness, elasticity, and scalability, hardware independency, customization, etc. (Sajid & Raza, 2013).
- Clustering is a set of independent IT resources that are connected to work together as a single system (Sadashiv & Kumar, 2011). This technology reduces system failure rates while increasing availability and readability, and these advantages are core to cloud platforms (Erl et al., 2013).

- Multi-tenancy refers to a principle where a single instance of software runs on a server and it can serve multiple customers simultaneously (Anstett et al., 2009). This technology is an important aspect of Cloud Computing, it provides cost efficiency since it decreases maintenance and upgrading costs (Dillon et al., 2010) and promotes customized services for the customers (Anstett et al., 2009).
- Web technology is generally used to provide management tools and medium for cloud services (Erl et al., 2013) since these services are provided over the network using a web browser (Sajid & Raza, 2013). Some examples of basic web technologies are Uniform Resource Identifiers (URIs) (Yang et al., 2014), Hypertext Transfer Protocol Secure (HTTPS) and Extensible Markup Language (XML) (Mather et al., 2009).
- Service technologies are vital for Cloud Computing because they provide a common mechanism for the delivery of services (Buyya et al., 2010). A web service is defined as a software system designed to support interoperable machine-to-machine interaction over a network (Warmer et al., 2009). Two examples of web-based services are Representational State Transfer (REST) (Rimal et al., 2011) and Simple Object Access Protocol (SOAP) (Mather et al., 2009). Another type of related technology is the Application Programming Interface (API), which is related to software-to-software communication (Erl et al., 2013). Mashups, where data from multi-web services are integrated together, are an important technology for Cloud Computing (Buyya et al., 2010). An example of a mashup service is the Google Maps application which is used to add location information to other applications. Service technologies are also important in Cloud Computing because they provide interoperability.
- Autonomic computing seeks to reduce human interaction with systems so that systems can cooperate with limited human guidance (Buyya et al., 2010). The concepts of autonomic computing may eliminate some concerns about Cloud Computing, such as privacy and security. This technology will enable self-provisioning of services, which is one of the main features of Cloud Computing.

2.5. Cloud Computing Architecture

The architecture of a cloud computing environment can be divided into 4 layers: the hardware or datacenter layer, the infrastructure layer, the platform layer, and the application layer (Zhang et al., 2010) as shown in Figure 2.2.

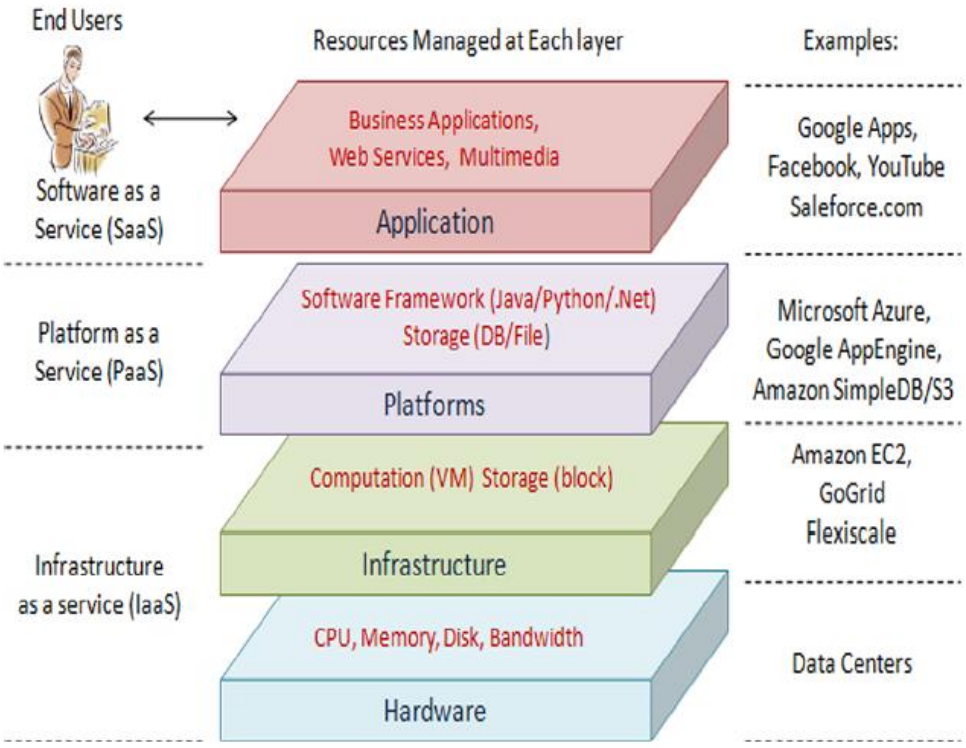


Figure 2.2. Cloud Computing Architecture Adopted from (Zhang et al., 2010)

The hardware layer is the first layer in cloud architecture which is dedicated to administering and directing the physical resources (e.g. physical servers, networking hardware). Hardware layer is in data centers which are used to provide accommodation for computer systems. The infrastructure layer is a detachable component of cloud computing which enables resource pooling. This layer which is also known as a virtualization layer provides a pool of resources by employing the virtualization techniques. The platform layer consist of platforms and operating systems and is built on top of the infrastructure layer and all the applications that are provided through cloud computing reside in the application layer that is the most accessible layer to the cloud user (Zhang et al., 2010).

2.6. Cloud Computing Service Model

A Cloud service model represents the services and the capabilities that will be offered via the cloud. The fundamental service models are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) (Mell & Grance, 2011). But the existing services are changed, and new ones are added to meet user needs (Rountree & Castrillo, 2013).

2.6.1. Software as a Service (SaaS)

Software as a Service (SaaS) is the most common and cost-efficient service that is provided by Cloud Computing (Armbrust et al. 2009). This service delivers applications running on a cloud infrastructure online and makes them accessible from different types of user devices either a thin client interface, such as a web browser (e.g., web-based email), or a program interface through the Internet (Mell & Grance, 2011). In this model, there is no need to install and run the application on the user's computer, and all maintenance and update procedures will be carried out by the service provider (Voorsluys et al., 2011). The users have control over their data only, while the service provider has full control of the underlying cloud infrastructure (Mell & Grance, 2011).

One of the main drivers of SaaS services is the delivery of service through a form of web-based applications, as the acceptance of web-based applications grows, so does the acceptance of SaaS services (Rountree & Castrillo, 2013). SaaS offers advantages over traditional packaged software as it lowers the cost of implementing the applications since there is no upfront cost required (Voorsluys et al., 2011). Additionally, maintenance and upgrade costs are decreased because these operations are carried out by the provider's (Mather et al., 2009). Scalability is another advantage of SaaS because organizations can scale their services based on consumer demand, using simple software configurations in a short time (Marston et al., 2011; Rountree & Castrillo, 2013). This feature is also important for start-up and small-and-medium-size organizations with minimal software requirements at the start and can be scaled up later.

Issues regarding SaaS are mainly related to the security and confidentiality of the data since the organization does not control the cloud infrastructure (Mather et al., 2009). Other potential issues associated with SaaS include ensuring service availability, since the access to a SaaS application is through the Internet (Mather et al., 2009), integration with other services and applications (Gupta et al., 2013) and vendor lock-in SaaS model, since the data format will be dependent on the service

provider format (Phaphoom et al., 2015). Google Drive, outlook.com, SalesForce.com are one of public SaaS providers (Rountree & Castrillo, 2013).

2.6.2. Platform as a Service (PaaS)

Platform as a Service (PaaS) provides the consumer to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider (Mell & Grance, 2011). The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment (Rountree & Castrillo, 2013).This model allows the users to maintain the complete application development lifecycle from designing until debugging the application (Hudaib et al., 2014). The potential users of PaaS are software developers since this model provides them with programming language execution environments, web servers and databases (Dai et al., 2012). PaaS enables rapid development of software applications at low costs (Mather et al., 2009). It is also useful in developing specific applications that require powerful computing resources such as big data analysis (Dai et al., 2012). The PaaS model can provide standardization for application development since it allows different teams to work on a single platform (Mather et al., 2009).

Several challenges come into play with public PaaS environments, including issues related to flexibility and security (Rountree & Castrillo, 2013). Cloud provider requirements are considered an issue when working with PaaS, for example, it may be that only specific programming languages can be used (Voorsluys et al., 2011). As with SaaS, lack of portability is also considered an issue with PaaS adoption (Phaphoom et al., 2015). PaaS model is relevant to a specific type of activities (i.e. application development), it is less popular than other types of cloud service models (Chuang et al., 2015).

Google App Engine and Microsoft Azure are a PaaS solution provider's that enable users to host their own applications on the same or similar infrastructure. Microsoft Azure provides a platform to build and execute .NET applications, Google App Engine enables users to develop and host applications written using Java, Python, and a new language called Go (Rountree & Castrillo, 2013).

2.6.3. Infrastructure as a Service (IaaS)

Infrastructure as a Service (IaaS) provides the consumer with Provision processing, storage, networks, and other fundamental computing resources where the consumer can deploy and run arbitrary software, which can include operating systems and applications (Mell & Grance, 2011). The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications and possibly limited control of select networking components like host firewalls (Mell & Grance, 2011). Comparing to the above two models (i.e. SaaS and PaaS), this model provides more flexibility for the user (Mousavi, 2013). The resources in this model will be utilized as virtualized resources and the consumer can control them using Virtual Infrastructure Manager (Voorsluys et al., 2011). In IaaS, computing services are offered as utility services and the user pays for computing resources used as a pay-per-use model where there is no need for upfront IT investment (Mather et al., 2009).

Many organizations look to IaaS providers to expand their capacity, instead of spending a lot of money expanding a datacenter or building a new datacenter and to provide a burst capacity only on certain occasions (Rountree & Castrillo, 2013). IaaS also provides cost savings because it does not require capital expenditure investment and the cost of infrastructure management comes under the cloud provider's responsibilities (Marston et al., 2011). As IaaS provides advantage to organizations there is also a concern, the possibility of losing control over the infrastructure leads to security issues (Lin & Chen, 2012). This security issue is seen as a more challenging issue in an IaaS environment because the consumer is responsible for all aspects of their application security (Mather et al., 2009). The total cost can also be an issue, in many IaaS environments, you are charged for resource usage, such as processor and memory (Rountree & Castrillo, 2013). Amazon's Elastic Compute cloud (EC2), Windows Azure Virtual Machines, Google Compute Engine, Rackspace are well known IaaS service providers (Rountree & Castrillo, 2013).

2.6.4. Other Service Model

The cloud is a collection of services, new services are constantly being created to meet user needs. These services lead to new service models in addition to the three traditional models (Rountree & Castrillo, 2013). In this section we will discuss new services other than the basic service.

- **Database as a Service (DbaaS)** provides a database platform, organization can use to store their data (Arutyunov,2012). Many PaaS providers also provide database services, but in many instances, organizations do not need a development platform, they simply need a place to store data models, in these cases, DbaaS option is a good choice (Rountree & Castrillo, 2013). Although storage prices are coming down, the cost is still high. A DbaaS implementation would include the database platform and the storage you need at a cost lower than what you could implement internally models (Rountree & Castrillo, 2013).
- **Desktop as a Service (DaaS)** is one of the newer service models being provided. In general, DaaS provides users with a virtual desktop that can be used to perform desktop computing (Rountree & Castrillo, 2013). Desktop as a service, also referred to as virtual desktop or hosted desktop services, is a multi-tenant architecture that is based on outsourcing of a virtual desktop infrastructure (VDI) to a third-party service provider (Mervat & Sarfraz, 2011).
- **Testing as a Service (TaaS)** The aim of this delivery model is to enable the organizations to do a realistic proof-of-concept test before they decide to transform their IT to the required cloud computing model via an emulator such as iTrinegy (Mervat & Sarfraz, 2011).. This service will allow the clients to monitor how significant factors can affect the network such as packet loss, bandwidth, latency, and response time for better decision making (Mervat & Sarfraz, 2011).
- **Network as a Service (NaaS)** is a category of cloud services where the capability provided to the cloud service user is to use transport connectivity services or inter-cloud network connectivity services or both services. NaaS services include flexible and extended VPN, Bandwidth on demand etc (Marco,2011).
- **Communication as a Service (CaaS)** category of cloud services where the capability provided to the cloud service user is to use real time communication and collaboration services. Communication and collaboration services include voice over IP, instant messaging, video conferencing, for different user devices (Marco,2011).

Table 2.1 presents a comparison between the three Cloud Computing Service Models The three models (SaaS, PaaS, IaaS) are the fundamental service models based on the NIST definition (Mell & Grance, 2011).

Features	SaaS	PaaS	IaaS
Control of resources (for all models, there is no control over the underlying cloud infrastructure)	Control is over the data only	Control is over the data and deployed applications	Control is over operating systems, storage, deployed applications, and data
Consumer type	End users without high-level IT skills	Software developers without specialized system administration skills	IT professionals with specialized system administration skills
Industrial Examples	Salesforce, NetSuite, Google Apps, Office 365	Microsoft's Azure Services Platform, Salesforce's Force.com, Google AppEngine	Amazon's Simple Storage Service (S3), Microsoft's Azure Services Platform

Table 2.1. Cloud Computing Service Model Comparison adopted from (Fawaz, 2017)

2.7. Cloud Computing Deployment Model

A cloud deployment model is defined according to where the infrastructure for the deployment resides and who has control over that infrastructure (Rountree & Castrillo, 2013). Each cloud deployment model satisfies different organizational needs, so it is important that you choose a model that will satisfy the needs of your organization (Rountree & Castrillo, 2013). Based on the NIST definition (Mell & Grance, 2011), there are four deployment types, which are outlined as follows:

2.7.1. Public cloud model

The cloud infrastructure is provisioned for open use by the general public (Mell & Grance, 2011). It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider (Mell & Grance, 2011; Rimal et al., 2011). Public clouds are environments that are entirely managed and serviced by an external service provider (Rountree & Castrillo, 2013). Popular commercial cloud providers include Amazon, Microsoft, Google, and Rackspace (Voorsluys et al., 2011). Examples of Cloud

Computing initiatives at governmental level are G-Cloud in the UK, Kasumigaseki Cloud in Japan, and the European Union's EuroCloud (Maqueira-Marín et al., 2017).

The number of public cloud implementations continues to grow at a rapid step due to the numerous benefits public clouds offer (Rountree & Castrillo, 2013). Public cloud can provide elasticity and scalability advantages since services are provisioned and released up or down based on customers' real needs (Pauly, 2011; Rountree & Castrillo, 2013). Public clouds offer the most savings in terms of upfront costs. Using a public cloud, organizations do not have to worry about spending money for initial hardware and software deployments, they pay for their actual usage as a pay-per-use model (Marston et al., 2011; Rountree & Castrillo, 2013). A public cloud can help countries that lack powerful IT resources, such as third-world countries, and allow them to provide better IT services (Marston et al., 2011).

Public cloud implementations do have their own set of limitations and drawbacks. A lot of these can be traced back to the fact that the infrastructure is owned and controlled by another organization (Rountree & Castrillo, 2013). Security becomes a key concern when adopting public cloud since organizations must move their data outside their premises and have less control over both physical and virtual assets (Mohapatra & Lokhande, 2014). Legal considerations regarding data protection and privacy regulations and data locations are obstacles to public cloud adoption (Marston et al., 2011). Application integration can also be a problem, different applications can use shared functionality where another application is able to call the functionality in another application. The application provider must expose APIs or web services that a customer can use to make this happen (Rountree & Castrillo, 2013). Forced downtime is also a problem, where the provider controls when systems are taken offline for maintenance. Maintenance may be performed at a time that is inconvenient for you and your organization (Rountree & Castrillo, 2013).

2.7.2. Private cloud model

The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units) (Mell & Grance, 2011). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises (Mell & Grance, 2011). Private clouds are completely managed and maintained by your organization (Rountree & Castrillo, 2013). The services and resources are accessible only

through a private company intranet (Naveen, 2013). The private cloud is applicable for large organizations that have enough resources since it provides the benefits of a public cloud with better security and control over the infrastructure (Marston et al., 2011). The private cloud differs from traditional IT due the implementation of virtualization technologies and self- service interfaces that allow scalability and per-usage metering features (Voorsluys et al., 2011). Private cloud is more expensive and secure when compared to public cloud (Savu, 2011). A private cloud can provide advantages over traditional IT such as cost reduction in software and maintenance activities, better transparency about the Total cost ownership (TCO), improved IT agility and better resource utilization (Marston et al., 2011).

Although having control over the environment provides you with many benefits in a cloud environment, it also have an issues with concerns about private clouds include high capital expenditure of IT infrastructure (Marston et al., 2011; Rountree & Castrillo, 2013), cost of migration (Lin & Chen, 2012) and lack of resources and expertise (Rountree & Castrillo, 2013; Mohapatra & Lokhande, 2014).

2.7.3. Community cloud model

The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns like mission, security requirements, policy, and compliance considerations (Mell & Grance, 2011). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises (Mell & Grance, 2011). A community cloud can offer the benefit of sharing computing resources and IT infrastructure which is regarded as one of the benefits of the public cloud (Mell & Grance, 2011). In a community cloud, costs are shared between the community members (Rountree & Castrillo, 2013). Additionally, this type of cloud deployment allows for more control of security requirements when compared to public cloud deployment (Mell & Grance, 2011).

The issues relating to the community cloud are around managing the heterogeneous systems of the community members and control over resources between the members thus ownership (Marinos & Briscoe, 2009). Ownership in a community cloud needs to be clearly defined. For multiple

organizations coming together to assemble infrastructure, they must determine some agreement for joint ownership (Rountree & Castrillo, 2013).

2.7.4. Hybrid cloud model

The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability like cloud bursting for load balancing between clouds(Mell & Grance, 2011). A hybrid cloud offers organizations the ability to keep critical services and data internally and outsource non-critical services to the public cloud (Marston et al., 2011; Naveen, 2013). Hybrid clouds can offer the best of both worlds as well as the worst of both worlds (Rountree & Castrillo, 2013). The hybrid model can offer better security and legal requirements since sensitive data will be inside the organization's boundaries (Mohapatra & Lokhande, 2014). The hybrid model can also be used to support specific activities such as backup and recovery and testing processes (Mohapatra & Lokhande, 2014).

Hybrid cloud implementation still faces some difficulties such as ensuring compatibility between different applications and devices (Rimal et al., 2011). A hybrid cloud environment can be the most complex environment to implement (Rountree & Castrillo, 2013). Integrating the different cloud architectures could lead to additional complexity in maintenance and configurations (Chang et al., 2014).

According to Mell & Grance (2011) cloud computing have four deployment models public, private, community and hybrid. Public clouds are open to the general public. Private clouds are specific to an organization. Community clouds are shared by multiple organizations. Hybrid clouds are environments made up of a combination of cloud models. Each model has its set of benefits, drawbacks, and security implications (Rountree & Castrillo, 2013). Table 2.2 shows a comparison between the four types of Cloud Computing Deployment Models.

Features	Public Cloud	Private Cloud	Hybrid Cloud	Community Cloud
Payment Model	Pay-per-use model	Total Cost of Ownership (TCO)	Combination of pay-per-use model and TCO	Total Cost of Ownership
Management	Public cloud provider	The organization or third-party provider	Public cloud provider and the organization	One or more organizations in the community or third-party provider, or some combination of them
Location	Outside the organization's premises	On or outside the organization's premises	On and outside the organization's premises	On or outside the organization's premises
Cost	Low: no upfront cost	High: upfront cost	Medium	Relatively cheaper than private and hybrid cloud
Security	Some security concerns	Fewer security concerns	Some security concerns but less than Public Cloud	Some security concerns
Consumer Base	Public (i.e. organizations of different sizes, individuals)	Single organization (usually large organizations)	Single organization	Group of organizations

Table 2.2. Cloud Computing Deployment Models Comparison adopted from (Rimal et al., 2011)

2.8. Drivers of Cloud Computing

The advantages that motivate organizations to migrate to cloud computing and highlighting the disadvantages helps them to come up with countermeasures and policies to prevent the possible failure (Mousavi, 2013). The benefits and advantages that drive organizations to adopt Cloud Computing are the followings:

- **Scalability and Elasticity:** A cloud environment can automatically scale to meet customer needs (Rountree & Castrillo, 2013). Cloud Computing scalability feature has led many organizations to implement this model (Fawaz, 2017). Scalability can help organization in two ways, First the increased capacity helps ensure that user needs are meet and the resources can be dynamically allocated on demand means that they don't always have to be available, which means you don't need to have systems waiting and sitting idle, this can

save utilization of resources such as power and cooling (Rountree & Castrillo, 2013; Mahesh et al., 2017). Scalability linked to elasticity, which refers to the ability of computing resources to be elastically provisioned and released up or down based on customers' real needs (Khanagha et al., 2013). Both features are important for organizations, allowing them to react to customers' needs quickly without the need to invest in extra IT resources (Pauly, 2011).

- **Improve IT agility:** Cloud Computing also improves organizations' IT agility as it enables them to reduce the time between identifying the need for a new IT resource and delivering it (Oliveira et al., 2014). In cloud environments you can easily assign resources when needed, this allows you to add resources to systems that need them and take them away from systems that don't and you can also easily add systems to expand your capacity (Rountree & Castrillo, 2013).
- **Ease of Maintenance**: Ease of maintenance can be a very attractive benefit of cloud computing. Since managing the infrastructure and the systems is responsibility of the cloud provider you don't have to worry tracking and staying up to date with the latest hardware and software patches, spending time trying to manage multiple servers and multitudes of disparate client systems and the downtime caused by maintenance windows (Rountree & Castrillo, 2013).
- **Improve availability of IT resources**: Cloud Computing delivers increased flexibility in using IT resources and improves availability of IT resources and business services by increasing system availability time (Weinman, 2012).
- **Increased Collaboration**: Cloud computing increases the collaboration of organizations (e.g. government agencies) to share data and information. In other words, cloud computing can improve data consistency and integrity among different related organizations and therefore, enable increased collaboration (Mousavi, 2013).
- **Time and Location Independent:** The information as well as the services are constantly available and can be accessed from anywhere and anytime through Internet connection (Mousavi, 2013). In addition, in a cloud environment all computing operations will be performed in the cloud, so the user can access from any device through a web browser or other thin client interfaces (Mell & Grance 2011); Marston, 2011). Thus, Cloud Computing

offers more mobility to users, enabling them to access computing resources anytime, anywhere and on any devices.

- **Better backup and disaster recovery services:** Cloud computing can provide mechanisms for automated scheduled network wide backup systems in order to store the data in off-site data centers (Mousavi, 2013). Cloud Computing can also improve backup and disaster recovery services since data may be stored in multiple locations at the same time, which will minimize the risk of the data being lost (Hsu et al., 2014).
- **Cost Reduction:** The main advantage of cloud computing which is also one of main incentives for governments and organizations to move to cloud is cutting the costs of IT infrastructure, since cloud allows pay as per our use, firms doesn't require high investment in infrastructure, they can simply take resources on rent (Mousavi ,2013; Trigueros-Preciado et al; 2013; Marston et al., 2011). By migrating to cloud, IT costs will be greatly reduced as there would be no need to purchase new hardware and install up-to-date software (Mousavi, 2013). Moreover, the routine maintenance costs and electricity costs would be minimized when migrating to cloud (Mousavi, 2013). Another economic benefit of cloud computing arises from converting Capital Expenses (CapEx) to Operating Expenses (OpEx) (Armbrust et al., 2009; Rountree & Castrillo, 2013). A Pay-per-use model allows organizations to pay for public cloud computing provision according to the actual consumption of computing resources without the need to invest in costly IT capital expenses (Chuang et al., 2015).
- **Allowing the delivery of new services, applications, and business models:** cloud computing helps organizations to provide new services that were not possible before due to the previously higher costs for IT solutions (Marston et al., 2011). Additionally, cloud computing can support organizations in the movement towards new business models and new markets (Marston et al., 2011).
- **Green Computing:** cloud environments can offer a greener environment because they enable multiple users to share common resources by serving according to users' needs. Hence, many data centers can be consolidated into one, it reduces the energy required for computing power and cooling and using renewable energy resources (Garg & Buyya, 2012).

- **Economies of scale and recurring revenue for cloud providers**: new cloud providers popping up every day, they see the benefits that can be obtained by offering cloud services (Rountree & Castrillo, 2013). Cloud providers make use of a concept called economies of scale. Once you build the infrastructure for an application or service, adding capacity will only require incremental additions. The larger the environment, the greater the potential return on investment (ROI) (Rountree & Castrillo, 2013). Another benefit of cloud for providers is recurring revenue which is offering subscription-based services can provide a service provider with a recurring revenue stream. Recurring revenue adds stability to a business (Rountree & Castrillo, 2013).

2.9. Challenges with Cloud Computing

A cloud computing has several benefits, but there are also some issues that have slowed cloud adoption (Rountree & Castrillo, 2013). Scholars identifies issues concerning cloud computing. The followings are issues with cloud computing:

- **Ambiguity:** One of the main reasons hinder the adoption of cloud computing is a lack of understanding of what cloud computing is and what it offers. This lack of understanding causes fears, usually these fears are around potential hidden costs, lack of control, integration issues, and security concerns (Rountree & Castrillo, 2013).
- **Vendor lock-in:** These issues are related to the dependency on cloud services vendors and these issues are portability and interoperability (Fawaz, 2017). While portability refers to the ability of organizations to move their data between different cloud vendors or back in house (Phaphoom et al., 2015; Zhang et al.,2010). Interoperability is the ability of different systems to exchange information (Lupşe et al., 2012). Both issues can lead to vendor lock-in, where customers can be locked into a single cloud vendor and unable to switch vendors without considerable cost and technical difficulties (Toosi et al., 2014).
- **General Security concerns:** Security concerns are the main discouraging factor of migrating to cloud for governments and organizations (Mousavi, 2013). Cloud computing has brought new security challenges, these include issues related to data confidentiality, integrity, and availability (Benslimane et al., 2014; Carroll et al., 2011). Data confidentiality refers to the prevention of unauthorized collection or disclosure of data (Avižienis et al., 2004). In a cloud computing environment, organizations use the cloud

provider's infrastructure to store data at the risk of exposure to a third parties, which increases the risk of data breach (Mather et al., 2009). An unauthorized access and alteration of data in the storage cloud and alterations to data by third party when it travels between the users and service providers are two issues related to storing data in the cloud in terms of integrity (Alvarez, 2011). Availability in cloud relates to ubiquitous access to data and applications for authorized users anytime, anywhere, on any devices. It is a major concern due to the nature of the cloud, whereby all services are made available mainly over the internet (Alvarez, 2011).

- **Concerns over maturity of cloud providers:** Many newer public service providers do not meet the needs of many organizations. Many of the services offered by cloud service providers are not robust enough to meet customer needs. Many public cloud services can be very specific (Rountree & Castrillo, 2013). The provider may only offer a very niche service. If your organization is not in need of a specific service presented in a specific way, you might not be able to take advantage of the service (Rountree & Castrillo, 2013). They also need to offer the right levels of service and support for those services (Rountree & Castrillo, 2013).
- **Service Level Agreement (SLA):** Many service providers are not at the point where they can offer truly substantive SLA. Some providers do not offer SLA at all. Others offer SLA but the service guarantees they make are not suitable for many organizations (Rountree & Castrillo, 2013). The demands of consumers vary significantly. It is not possible to fulfill all consumer expectations from the service provider's perspective and hence, a balance needs to be made via a negotiation process (Dubey, 2016).
- **Performance:** Another issue related to the technical side of cloud computing is performance, which refers to the ability to deliver a specified job within a given time (Chang et al., 2014; Phaphoom et al., 2015).
- **Data integration and application or service integration**: When dealing with public service providers, you do not own the systems used by the service providers and have direct access to them (Rountree & Castrillo, 2013). Without direct access, some sort of interfaces must be provided to allow for integration with your other systems both with data integration and application integration (Rountree & Castrillo, 2013). Integrating data and reporting between on-premises and cloud-based systems can be costly. You will have to figure out a

means of copying large amounts of data from one location to the other (Rountree & Castrillo, 2013).

- **Reliability**: Reliability is another concern for organizations that are planning to adopt cloud computing because they need to ensure constant operation of their IT services (Güner & Sneiders, 2014). Reliability refers to the capability of the cloud provider to offer continuity of IT services in the case of system disruption, reliability can be improved via utilization of redundant resources (Chang et al., 2014).
- **Legal Issues:** Legal issues are another main discouraging factor for migrating to clouds (Rountree & Castrillo, 2013). The defined rules and regulations in cloud computing mainly stress on different approaches in access control (Chandrasekaran, 2015). Legal and compliance issues also get very complicated when cloud is implemented because jurisdiction is not defined clearly. If you are in the United States and accessing servers in Europe, which regulations apply? In general, the guidance is to make sure you adhere to laws in both jurisdictions (Rountree & Castrillo, 2013).
- **Internet connectivity concern:** Since cloud services can be accessed through the internet, speed of the internet is one of the major considerable factors. Sometimes due to lowered internet connection one cannot access files from the cloud, it may lead to huge loss in the corporate world (Doherty et al, 2015).

There are many factors pushing organizations toward the cloud, as well as many factors that are keeping organizations away. Each organization must evaluate cloud offerings for itself to see what best fits its needs (Rountree & Castrillo, 2013).

2.10. Cloud Computing in Telecommunications Sectors

Cloud computing is one of the key business and technology trends impacting every aspect of the ICT industry (Vajda, 2012). Cloud computing brings a new way of doing business, characterized by a shift from capital expenses to operational ones and turns traditional IT products into services provided on demand basis, usually remotely (Vajda, 2012). Because of efficiencies, convenience and pay-per-use pricing model, cloud computing is attractive to consumers and businesses (Vajda, 2012). Cloud computing has become a major topic within the telecommunications industry as operators begin to position themselves as a service and application providers (Katica & Tahirovic, 2012). There are two main reasons why network service providers should consider becoming

engaged in cloud computing (Jan et al, 2010). The first is to gain the benefits of cloud computing for IT optimization like lower costs, and more elasticity and speed. The second is to exploit new business opportunities (Jan et al, 2010). In foreign countries, in addition to providing ISP network services to the public, Orange, O2 and other large telecommunications companies also serve as a cloud computing service provider (Zhou et al., 2014). These companies provide IDC equipment rental and SaaS product application services to different industries (Zhou et al., 2014).

In the next section the role of telecom operator in cloud computing from different perspectives, benefits of cloud computing from telecommunication/ICT perspectives with application of cloud computing in different telecom operators and finally the concerns of cloud computing in telecommunication sectors will be discussed.

2.10.1. Role of cloud computing in telecom operator

Telecom operators are spending a lot of money to maintain and enhance their network, while other cloud providers are monetizing the networks, at the expense of telecoms. Telecom operators are uniquely positioned to take advantage of cloud business opportunities (Ericson, 2012). They have comprehensive network capabilities (broadband and mobile), long experience with integrating information technologies (IT) and other services into their network and delivering those services to the customers (Ericson, 2012). Telecom operators align themselves in cloud value chain as cloud service providers, cloud service users and both as users and providers (Ericson, 2012).

❖ Telecom Operator as Cloud service Provider

Telecom operators can provide managed connectivity between cloud users and third-party providers, offering flexibility in network resources both in real-time and on-demand. Telecom operators can align themselves in the cloud value chain as providers in three ways, by managing cloud connectivity, by delivering cloud-based capabilities and by leveraging network assets to enhance cloud offerings (Ericson, 2012). Figure 2.3 show telecom operators three roles as cloud service provider (Ericson, 2012)

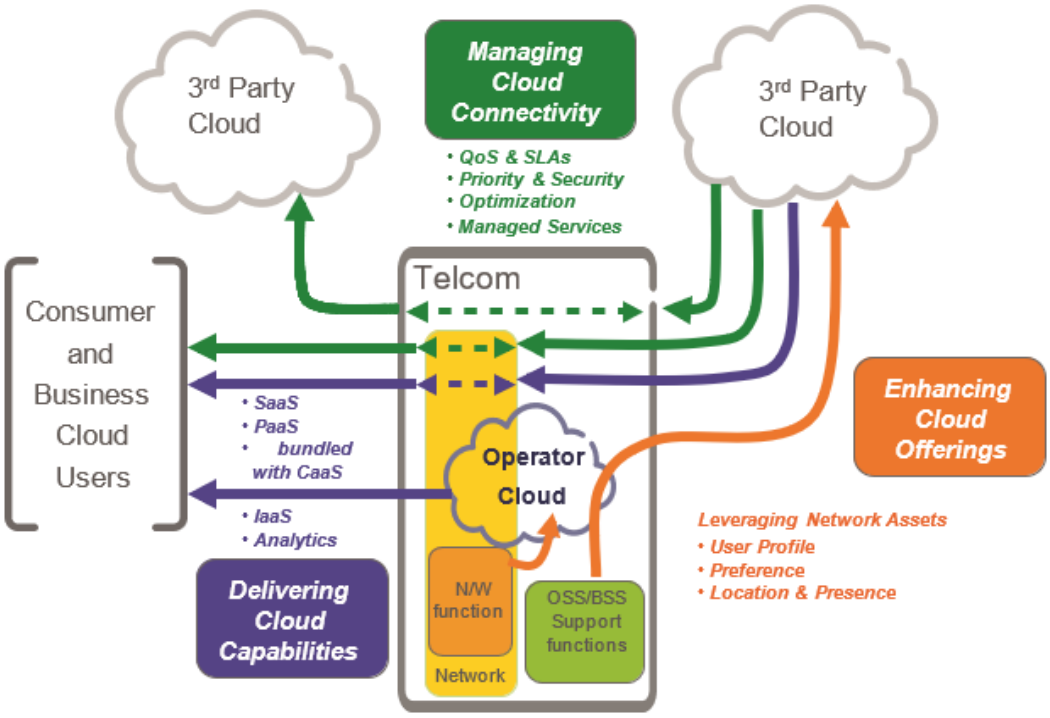


Figure 2.3. Telecom operators three roles as cloud service provider (Ericson, 2012)

- **Managing cloud connectivity:** Operators are in a unique position to provide managed connectivity between cloud users and third-party providers, offering flexibility in network resources both in real-time and on-demand. Operators can offer connectivity services to enhance the user experience of cloud applications and there are also possibilities for operators to offer device management, on top of end-to-end network management (Ericson, 2012).
- **Delivering cloud-based capabilities:** Telecom operators can partner and resell third-party SaaS and PaaS offerings bundled with their own services, or they can invest in the infrastructure and deliver both third-party and their own offerings on that infrastructure more efficiently. By having in-house data centers, not only can telecom operators, they can also provide IaaS in the form of on-demand hardware and computing platforms (Ericson, 2012).
- **Leveraging network assets to enhance cloud offerings:** Telecom service providers can embed attributes (for example, user preferences, activities, and analytics) with third-party cloud offerings, enhancing their value by making them more relevant and meaningful to

users. Furthermore, telecom operators can strengthen their relationships with end-users and third-party providers by acting as a service and billing aggregator (Ericson, 2012).

❖ Telecom Operator as cloud user

Telecom service providers operate in a complex operational environment, heavily dependent on technologies to run their networks and support the delivery of their services. Adoption of cloud services can lead to efficiency gains, operational flexibility, and substantial cost savings for telecom operators. Telecom operators can be benefited as users of cloud computing in two ways (Ericson, 2012).

- By building cloud infrastructure, they can transfer selected business functions and computing requirements to cloud, they can become their own customers by migrating their existing services and support functions onto the shared infrastructure, thus reducing their total cost of ownership (Ericson, 2012).

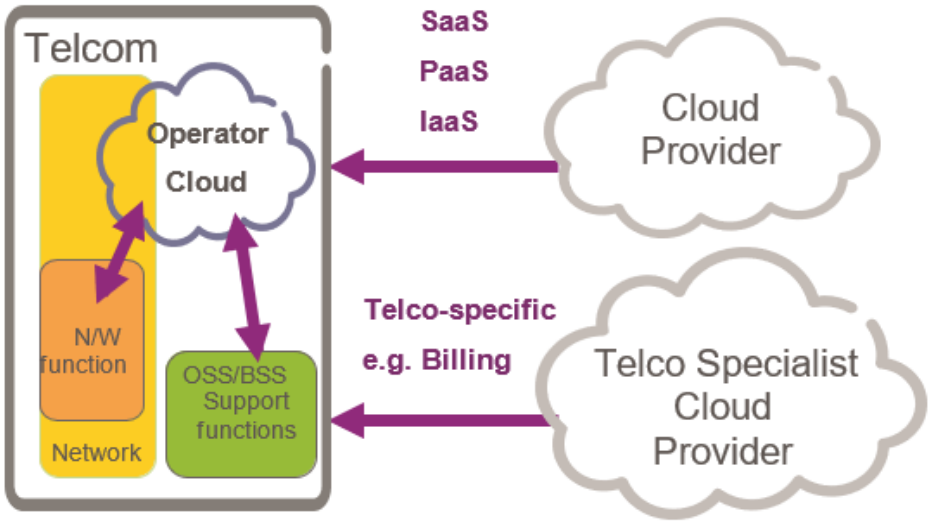


Figure 2.4. Telecom Operator as Cloud user (Ericson, 2012).

- At the same time, they can be both a user and providers. In traditional telecom functions like OSS/BSS, where a telecom operator outsources its billing and customer care to an OSS/BSS specialist while partnering with the specialist to offer that functionality to other enterprises (Ericson, 2012).

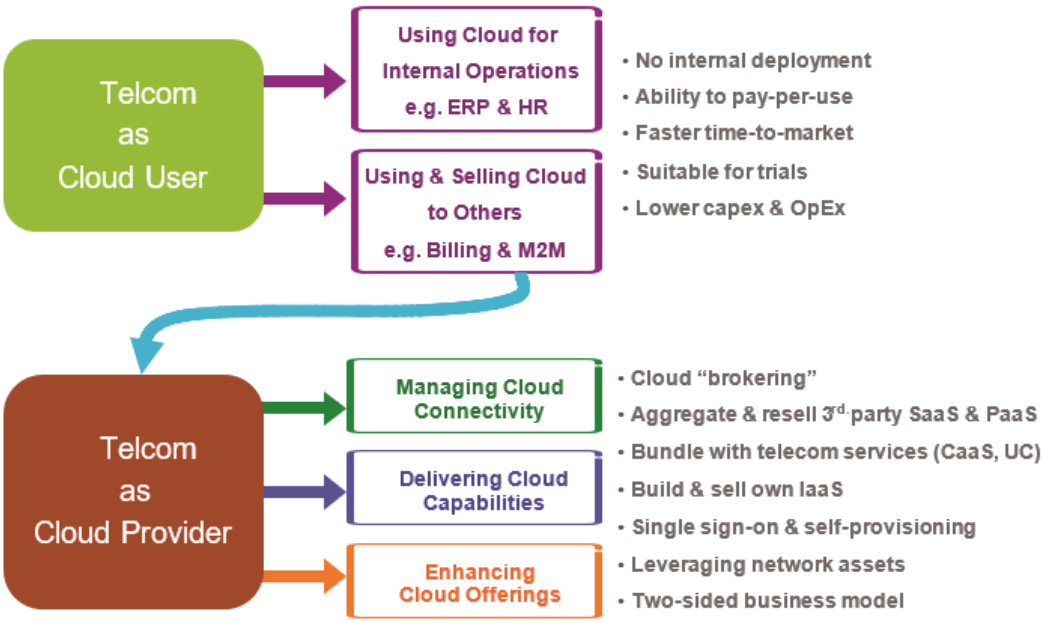


Figure 2.5. Telecom Operator as Cloud User and Service Provider (Ericson, 2012)

2.10.2. Benefit of Cloud Computing in telecom

According to (Zhou et al., 2014) benefits of cloud computing could be considered from the different perspectives of players in the cloud ecosystem, these players are service providers, partners, and users. The general benefits of cloud computing from telecommunication/ICT perspectives can be summarized as:

- Cloud delivery model as a converged platform to deliver IT and communication services over any network (fixed, mobile, and worldwide coverage) and used by any end-user connected devices (PC, TV, Smartphone, machines, etc.).
- Deliver a rich set of communication services (voice and video calls, audio, video and web conferences, messaging, unified communications, content creation, workspace, broadcasting, etc.) according to a cloud multi-tenant consumption-based usage model and creating mashups with web 2.0 collaborative services for communication as a service (CaaS).
- A network services (L2-L3 connectivity, and VPN and L4-L7 network services) as smart pipes "high-grade networks" for cloud service transport and cloud interconnection (inter-cloud) in order to guarantee a secure and high-performance end-to-end quality of service (QoS) for end users.

In addition to these benefits, some other benefits can be also considered from the service provider, partner, and user perspectives (Zhou et al., 2014). In western countries different telecom operators are providing cloud service to its customers. France Telecom, Shanghai Telecom, and SK Telecom have piloted IBM Cloud Service Provider Platform. Its Orange business services unit is using IBM services to provide IaaS to business customers, optimized cloud networking, Security-as-a-Service, Real Time applications as a Service and cloud-related support. On the other hand, Huawei along with its partners, specifically with Cisco systems, and Google is en-route to providing cloud services to IT and CT (Communications Technology) field. Huawei is also providing Cloud Desktop and Virtual Calling Center Desktop (Wan, 2010). Norway's Telenor Connexion is offering its M2M services through a dedicated platform leased from Ericsson. The platform is part of Ericsson's cloud-based Device Connection Platform portfolio (Ericson, 2012).

2.10.3. Telecoms Concerns in the Cloud

While the opportunities associated with cloud computing appear to be very attractive, there are challenges that need to be considered in telecom industries. The main challenges are the availability and security (Katica & Tahirovic, 2012). Companies and consumers often do not want to store their data in the cloud due to a lack of trust and the risk of exposing their data in an un-trusted environment (Katica & Tahirovic, 2012). A cloud provider must comply with security solutions in telecom addressing integrity of data, availability of service, accountability of offerings, confidentiality of privacy data, and authenticity of user-access issues (Cloud Security Alliance, 2009). Another challenge is application migration concerns, Manual upgrading to cloud deployments or even making cloud deployments is encouraging to errors, automating upgrading process is needed along with defining clear servicing of applications (Sailer, 2010). A cloud provider or a vendor who is providing SaaS should address latency since different cloud providers are incapable of providing telecom-grade latency solutions (Wan, 2010). Intra-cloud latency adds up to the network or internet latency to give total systemic latency so it should be addressed (Wan, 2010).

2.11. Cloud Deployment Model Selection Criteria

Based on the applications, attributes and business requirements of an organization, a Cloud can be deployed in several different ways (Rahul & Prince, 2013). There are four deployment models for cloud computing public, private, hybrid and Community (Mell & Grance, 2011). Each Cloud

deployment model satisfies different organizational needs (Rountree & Castrillo, 2013). Every Cloud deployment model offers different advantages and constraints, many organizations find it as a great decision challenge when identifying the right deployment model that will optimally address their business needs (James & Tridip, 2015). All enterprises have to choose one of the four deployment models in order to implement a Cloud computing solution, depending upon the organizational specific business needs, context, the capability of enterprises, firm size and top manager interest they can adopt different cloud computing deployment models (Young-Chan et.al , 2012; Zhang et al., 2010).

Different studies have been conducted. A study on factors needs to be assessed by the organization to adopt a cloud computing deployment model and comparison between different cloud models. Some of the related work is discussed in the following section.

Cloud Standards Customer Council [CSCC] (2014), identified six requirements or considered factors to determine which cloud deployment model best suits a business need. These factors are criticality of cloud services ,types of workload, elasticity ,migration costs ,security threats and multi-tenancy. Compliance, environment portability and disaster recovery or failover are new factors to determine the best suit cloud deployment model in addition to the factors found earlier (Cloud Standards Customer Council [CSCC], 2017a).

Object Management Group ([OMO], 2019) emphasized that the selection process of cloud deployment models should encompass both strategic and tactical. Strategic selection should consider the business needs and corporate cloud strategy and determine which cloud deployment technologies are relevant while tactical selection should address specific application or service needs (OMO ,2019). They identified a three-step procedure for selecting a cloud deployment model. These steps are, first assess the fit of cloud deployment technologies to the business needs with cost, architectural fit, performance, compliance, elasticity requirements, control requirements and CSP lock-in as key considerations. Secondly, identify requirements related to the types of workloads or services being deployed in the cloud like strict latency limitations and data protection controls and lastly, select application or service cloud deployment technology requirement (OMO ,2019). The selection criteria are those from business needs and workload or service requirements (OMO ,2019).

Mahyar et.al (2013) conducted a study to identify the factors that influence the organization to select between the private and public cloud computing. The study identifies the organization's type, organization's business, firm size, and top manager interest of the organization are factors that influence the organization to select the deployment models. The study recommends for the well-defined IT infrastructure such as enterprise and government organizations, the private cloud computing is more suitable to them and for the organization that wants to have greatest level of security and control over their application and resources since organization have its own firewalls to handle the security issues **(**Bider & Perjons ,2010). For most startup new the organization, the public cloud computing is best fit (Mahyar et.al, 2013). The study is only limited to Private and public cloud models, hybrid and community models are not included.

Mustafa et.al.,(2015) investigated the relevant characteristics for deciding on the best combination of cloud delivery service (SaaS, PaaS, or IaaS) and deployment models (public, private, hybrid, and community) that fits the organizational requirements. The authors classified the characteristics into services delivery characteristics and deployment characteristics. The identified relevant characteristic for selecting a cloud deployment models are cost of cloud deployment (Initial capital cost and additional operating cost), security and privacy of data which includes data integrity, level of audibility and access control, control of service or data. The authors proposed a mapping between two sets of characteristics of cloud computing models. The same authors proposed an expert system to support management decisions with respect to adopting the right cloud service delivery and deployment models, while satisfying organizational conditions and computing requirements (Mustafa et.al.,2018). The authors identified level of industry integration as additional characteristic for selecting cloud deployment models.

Karandeep (2016) emphasizes that depending upon the priorities and needs of the organization, a cloud infrastructure can be chosen by organizations. The study described some parameters which are relevant to most of the SMEs and large organizations as well as individual users for selecting a cloud deployment model. These parameters are scalability, security, reliability, cost of use, data and application integration, system management, portability, tools and skills, data handling and workload. The study recommends different cloud models can be chosen depending upon the specific needs of the enterprises with comparing the strengths as well as the weaknesses of the models.

Another study investigated how to choose an economic cloud computing deployment model based on applications, attributes, and business requirements of an organization. The author explored and compared each cloud model with a scenario and application have for which an organization could options to adopt. The author also presents eight points that need to be known by an organization before adopting a cloud computing and steps to choose an economic deployment model. These steps includes review contract of model, access cost and investment to the model, maintain standard with the model, troubleshooting by the model, performance by the model, privacy and control policies of the model ,risk management given by the model and network dependency in the model (Rahul & Prince, 2013).

In 2012,Young-Chan et.al proposed a decision model for cloud computing deployment. The authors use the combination of analytic hierarchy process (AHP) and benefit-cost-opportunity-risk (BCOR) analysis to select the best cloud computing deployment model with a holistic view based on the benefit, cost, opportunity, and risk factors. The hierarchy for the benefit aspect contains five factors. Economic, managerial, satisfaction ,efforts and time benefits while a cost hierarchy contains cost of infrastructure, deployment or implementation ,maintenance, switching, service, and human resource. Cost saving, expansion and innovation are factors under opportunities hierarchy while lack of control, security, recovery, internet latency, vendor lock-in and concern associated with data access and integrity are under risk hierarchy.

James & Tridip (2015) proposed a collaborative decision-making framework for selecting a cloud deployment model by using the application of Delphi analytic hierarchy process (DAHP) method. The authors identify factors like security, usability, serviceability, availability, reliability, scalability, interoperability, complexity, and costs need to be assessed while selecting a cloud computing deployment model with specific needs of the organizations. Ahmed (2012) in his study makes a comparison of cloud deployment models based on scope of the service, owner of the service, management of the service ,security level and locations of service. A similar study also conducted by Chandrashekhar & Shashikumar (2017), compares public and private cloud in terms of resource accessibility, security, infrastructure deployment and cost.

Based on literature review cost efficiency, security and privacy, data and application integration, scalability, performance, reliability, portability, ownership, user control and criticality of cloud

service and types of workload are parameters used to select a best fit cloud deployment model for Ethio telecom.

Factors /Considerations	Description	Source
Cost Efficiency	Efficiency of Cost associated with initial cloud deployment cost and additional operating cost including maintenance cost. *(Low/Medium/High)*	Mohammad & Rafiqul (2018); Guruh et al (2018); Rao et al, (2016) ; Saripalli & Pingali, (2011) ; Williams, (2012); Buyya et al.,(2009); Hauck et al.,(2010); Marinescu,(2013); Zardari et al., (2014)
Privacy and security	Expectation that the cloud model will only provide access to authorized, authenticated users, level of audibility, data integrity and those users need to be able to trust that their data is secure, and risks associated . *(Low/Medium/High)*	Garg, et al.,(2013) ;Güner & Sneiders, (2014) ; Morgan & Conboy, (2013); Sun, et al., (2014) ;Rao et al(2016); Ahmed (2012); Mohammad & Rafiqul (2018); Guruh et al (2018) ; Buyya et al., (2009); Hauck et al., (2010); Marinescu, (2013); Zardari et al., (2014)
Data & Application Integration	The ability of cloud model to integrate seamlessly, data and application across clouds, between cloud and local applications. *(Low/Medium/High)*	Garg, et al., (2013);Güner & Sneiders, (2014); Morgan & Conboy, (2013); Sun, et al., (2014); Mell & Grance, (2011)
Scalability	Expectations that the cloud model can increase or reduce its performance, resources, and functionalities according to user's needs and allows to optimize the overall efficiency of the system and get cost-savings. *(Low/Medium/High)*	Guruh et al (2018) ; Rao et al(2016); Rountree & Castrillo, (2013); Chandrasekaran, (2015)
Performance	The cloud model should not introduce complexities or difficult, such as by introducing	Mohammad & Rafiqul (2018); Rao et al. (2016); Rountree & Castrillo, (2013); Chandrasekaran, (2015)

	virtual applications and process that can affect the performance and serviceability. *(Low/Medium/High)*	
Reliability	Expectation that applications will not fail and most importantly they do not lose data. The architecture is designed such that applications will continue to operate, and their data remains intact despite the failure of one or more of the servers or virtual machines onto which they are decomposed. (Low/Medium/High)	Mohammad & Rafiqul (2018); Rao et al (2016); Rountree & Castrillo, (2013); Chandrasekaran, (2015)
Portability	The ability of cloud model to move application and data from one cloud computing environment to another with minimal disruption. *(Low/Medium/High)*	Rao et al ,(2016); Rountree & Castrillo, (2013); Chandrasekaran, (2015)
Ownership and user Control	The organization status to own the cloud model and degree of cloud model controlled by organization. *(Low/Medium/High)*	Ahmed (2012); Mohammad & Rafiqul (2018);Guruh et al (2018); Güner & Sneiders,(2014); Morgan & Conboy, (2013);
Criticality of cloud service and types of workload	The degree of cloud model capability for mission critical service and for a very stringent latency requirement. *(Low/Medium/High)*	CSCC,(2014); CSCC,(2017a); OMO,(2019).

Table 2. 3 Cloud computing deployment model comparison criteria

2.12. Related work

Many studies in the field of Information Systems (IS) have investigated significant factors influencing the adoption of new technologies or service solutions. However, research on Cloud computing deployment model is less explored in Telcom industry. Most of the literature on Cloud computing has focused on Cloud computing architecture, potential applications, Cloud computing costs and benefits, factors affecting cloud computing adoption and readiness assessment of

organization to adopt cloud computing. In this section related study work in cloud computing is discussed specifically on Telecommunication sectors.

Ramzan et al. (2018) Conducted a study to identify factors and issues addressed while implementing and deploying cloud computing in telecommunication sectors. Empirical qualitative and quantitative research methodology is used to identify the obstacles faced for implementing and deploying CC in various telecom industries. The study identified that the two most important barriers for using CC are security issues and transferring data to a third party. while unawareness of the managers on how to calculate the results produced by CC, benefit of cost by using CC, quality, availability of services, and requirements for data protection are also barrier for using CC in telecom sectors. The study recommends identifying factors and issue that hinder implementation and deployment of CC in other telecommunication sectors.

Satheesh & Rao (2016), conducted a study with objective to improve the end-to-end performances of cloud mobile media delivered through mobile cloud computing systems by studying operation of cloud computing and wireless networks in mobile computing environments. They were studied the issues that arise when jointly using the operations of cloud and wireless networks in mobile cloud computing environments with the telecom operator cloud. They proposed a homogeneous Bertrand system model to simulate CMM SPs and HWNs with small cells. The simulation results show that the dynamics of cloud operations have a significant impact on the heterogeneous wireless network, and joint optimization is necessary for the operations of cloud and wireless networks. By jointly optimizing the operations of clouds and wireless networks, the proposed scheme can significantly improve the performance of the mobile cloud computing systems.

Zhou et. al, (2010) also Proposed a Service Storm, a novel self-service telecommunication Service Delivery Platform with Platforms- a-Service technologies to support rapid and flexible construction and delivery of value-added services in the cloud environment as an open developer community. The proposed model includes a rapid assembly model and tools for codeless and off-premise integration of telecom services and application logic based on Web 2.0 technologies, Cloud based resource isolation, management, capacity planning and scaling for dynamic topology deployment and elastic infrastructure support, and Automatic deployment and monitoring in runtime. The model is also tested with SMS and Web based mobile how these technologies and

architectures enable the new business model for telecommunication operator. The finding shows that Service Storm has provided more flexibility and conveniences to the individual and organization users and helped them save invest and cost. With the increasing amount of the end users the telecommunication operator and business partner of Service Storm can win more profit and significantly enhance the diversity of value-added services with lower cost and shorter time to market. The study is also recommends enhancing the elements of service assembler and the security of the deployed solution environments.

In the case of Ethiopia there are a few pieces of research conducted on cloud computing areas. Alemayehu (2014), investigated the readiness of seven selected organizations from four different sectors located in Ethiopia, investigated using the Technology Organization Environment (TOE) framework and produced a strategic guideline that could be used by Ethiopian organizations for the successful adoption of cloud computing. The researcher used interview as a data collection method. The research is not specific for the telecom sector and recommends researchers to apply the strategic guideline on other industries since the result of the study cannot be generalized.

Birhane (2018) also conducted a study to identify determinants that influence the decision of small and medium enterprises to adopt cloud computing in Ethiopia and what effects firm size have on cloud adoption decisions. The researcher proposed a conceptual cloud adoption model that predicts the cloud deployment model with the specific need of the organizations grounded by Technology Organization and Environment (TOE) and Diffusion of Innovation (DOI) frameworks. According to the model, six variables are identified that influence the decision to adopt CC in Small and Medium enterprise. To test the model of the researcher, use a questionnaire as a data source and recommend further research to test and confirm the proposed conceptual model in other location in Ethiopia.

In the case of Ethio telecom there are three pieces of research done on cloud computing. A study was conducted by Ruth in 2017 to assess the readiness level of Ethio Telecom to implement cloud computing services using the STOPE model. A mixed research method was used. Interview was used to gather qualitative data and a survey was used to gather quantitative data. The study shows that strategy has a strong relationship with Technology, Organization, People and Environment. The lack of Readiness to implement cloud computing affects all domains especially organizations and people readiness to adopt cloud computing (Ruth,2017). The researcher recommends using a

different framework to assess readiness level if any improvements could be observed. The study did not identify whether Ethio telecom is eager to adopt cloud computing, what potential deployment model is best fit Ethio telecom needs and factors affecting the adoption of the potential deployment model.

Ethio telecoms recently implemented desktop cloud computing infrastructures analyzed and assessed by Lily in 2017, the impact and technical advantage they brought to Ethio telecom specifically in the customer service division. A qualitative research method and interview, questioners, and observations as data collection techniques was applied in the study. The study shows that desktop cloud computing brought a positive impact on the call center's service quality and work environment . The study recommends a future work on developing a virtualized network for the desktop cloud system of call centers (Lily,2017). This research shows us that Ethio telecom has a willingness to adopt cloud computing but the level of readiness to adopt cloud computing is not clear and what factors affecting the adoption of the potential computing model is not studied.

In other studies, a carrier-based cloud service architecture proposed by taking the client's profile and requirement as a context (Aschalew, 2018). The focus of this study is to assess what kind of cloud service (IaaS, PaaS, and SaaS) Ethio telecom gives to its clients. By using design science research methodology (DSRM), Questionnaire and Interview for design and Validation, the study proposed a conceptual carrier-based cloud service architecture taking into consideration client's requirements and the capability of the carrier. The architecture was designed with three major components, namely Infrastructure as a Service (IaaS), Cloud Service Broker (CSB) and telecom capability services. The architecture has also incorporated the Service Oriented Architecture (SOA) based Enterprise Service Bus (ESB) architecture for dynamically configurable virtualized services. The study did not identify what potential deployment model is best fit Ethio telecom needs. Table 2.3 shows summaries of related studies that have been conducted on cloud computing.

Authors	Objective	Methods	Findings
Ramzan et al (2018)	To identify factors and issues addressed while implementing and deploying cloud computing in telecommunication sectors	Mixed research	The study identified that security issues and transferring data to a third party are the two most important barriers for using CC in telecommunication sectors.
Satheesh & Rao (2016)	To improve the end-to-end performances of cloud mobile media delivered through mobile CC systems by studying operation of CC and wireless networks in mobile computing environments	Design Science Research	They proposed a Bertrand system model to simulate CMM SPs and HWNs with small cells. The simulation results show that the dynamics of cloud operations have a significant impact on the heterogeneous wireless network, and joint optimization is necessary for the operations of cloud and wireless networks.
Zhou et al (2010)	To propose self-service telecommunication service delivery platform that attract and serve an expanded customer base telecommunication service provider need.	Design Science Research	Proposed a Service Storm, a novel self-service telecommunication Service Delivery Platform with Platforms- a-Service technologies to support rapid and flexible construction and delivery of value-added services in the cloud environment as an open developer community
Alemayehu (2015)	To investigate the readiness of the selected Ethiopian organizations for the adoption of Cloud Computing and propose A Strategic Guideline for adopting cloud computing.	Qualitative research	Proposes a Strategic guideline that could be used by Ethiopian organizations for the successful adoption of CC
Birhane (2018)	To propose a cloud adoption framework for Small and medium enterprise	Mixed research	Proposed a Cloud Deployment Selection Model (CDSM) to

			support SMEs' in predicting an appropriate cloud model for their business need.
Lily (2017)	To analyze and assess the impact of the implemented Desktop cloud computing infrastructure and usage in Ethio telecom specifically in customer service division and to address implementation gap.	Qualitative research	The study shows that desktop cloud computing brought a positive impact on call center's service quality and work environment
Ruth (2017)	To assess the readiness level of Ethio Telecom to implement cloud computing services.	Mixed research	Strategy has a strong relationship with Technology, Organization, People and Environment and Ethio telecom lack readiness to implement cloud computing
Aschalew (2018)	To generate carrier-based cloud service architecture taking the client's profile and requirement as a context.	Design Science Research	The study proposed a conceptual carrier-based cloud service architecture taking into consideration client's requirements and the capability of the carrier.

Table 2.4. Summary of Related Works

2.13. Chapter Summary

This chapter has provided a literature review of Cloud Computing covering the fundamental aspects of the cloud model, which is an emerging model of delivering IT services. The development of ICT, Cloud Computing and various Cloud Computing definitions were reviewed and discussed. The essential characteristics of Cloud Computing were presented, followed by a brief description of its enabling technologies, such as virtualizations and multi-tenancy. Then discussion of various deployment models (i.e. public, private, hybrid and community) and the basic service models (IaaS, SaaS, and PaaS), and new emerging service types was also provided. The main drivers and challenges of Cloud Computing adoption were discussed. The role of cloud computing in telecommunication sectors is also discussed.

The findings of this chapter have also shown that there is a need for further investigation of the adoption of Cloud Computing in Ethiopia specifically for Ethio telecom. There is a gap in what kind of cloud computing deployment model best fit Ethio telecom needs and the readiness level of the Ethio telecom to adopt the potential deployment model. This is because each cloud deployment model satisfies different organizational needs and needs different readiness levels of the organizations and different value proposition and different costs associated with it (Rountree & Castrillo, 2013). In the business perspective, making the correct decision regarding the deployment model is very important since a model should be selected based on the needs, requirements, budget, and security (Chandrasekaran, 2015). There are many users of the cloud, and each user has different needs. One deployment model will not suite all the cloud users (Chandrasekaran, 2015). Based on the cloud setup, the properties of the cloud change (Chandrasekaran, 2015).

Therefore, it is the right time and worth to study what kind of cloud computing deployment model best fit Ethio telecom and need to identify the readiness level of Ethio telecom to adopt the potential deployment model. Thus, the next chapter will discuss the method and design of the research methodology.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Overview

The research design and methodology chapter provide the blueprint as how to collect data and link the data to be collected (and the conclusions to be drawn) to the initial questions of the study. The main aim of this chapter is to discuss the research design and methodology used to carry out this research. The chapter is divided into different major sections. The first section is about the research strategy then the research approach is described and covers the reasons for the selection of this strategy. Research approaches and the sampling design and sampling techniques will be discussed. Issues on research techniques are presented such as data collection techniques, analysis strategy, and validity and reliability measures that are applied to ensure the consistency and quality of the research. Finally, a cloud deployment model selection criteria and readiness assessment method used in this study are discussed.

3.2 Research Design

A research design is a plan used as a guide in collecting and analyzing research data for the study to be conducted. It describes the methods used to collect and analyze the data that helps to answer the research question. Research design is a blueprint or guidance of the research (Kothari, 2004). This section discusses the steps used in this research, research approach, research strategy and sampling and sampling methods.

3.2.1. Research Process

Research can be represented as a process that requires a series of steps to be completed (Fawaz, 2017). The following steps were used in this research

- Literature Review: This research starts with a literature review focusing on key concepts from the areas of cloud computing, deployment model and service types and related study on cloud computing.

- Ethio telecom current IT infrastructure, service types, business application and IS strategy documents were reviewed for understanding Ethio telecom needs.
- Develop a deployment model that meets Ethio telecom needs, then a model was given to domain experts to give a feedback.
- A final Deployment model was proposed based on experts' feedback and evaluations.
- Then, the readiness level of Ethio telecom to adopt the proposed deployment model.
- Based on the Readiness level of Ethio telecom the proposed model enhanced with current state of the company.
- Finally, the thesis was conclude with a summary of the findings and recommendations on future works. Figure 3.1 shows the research steps.

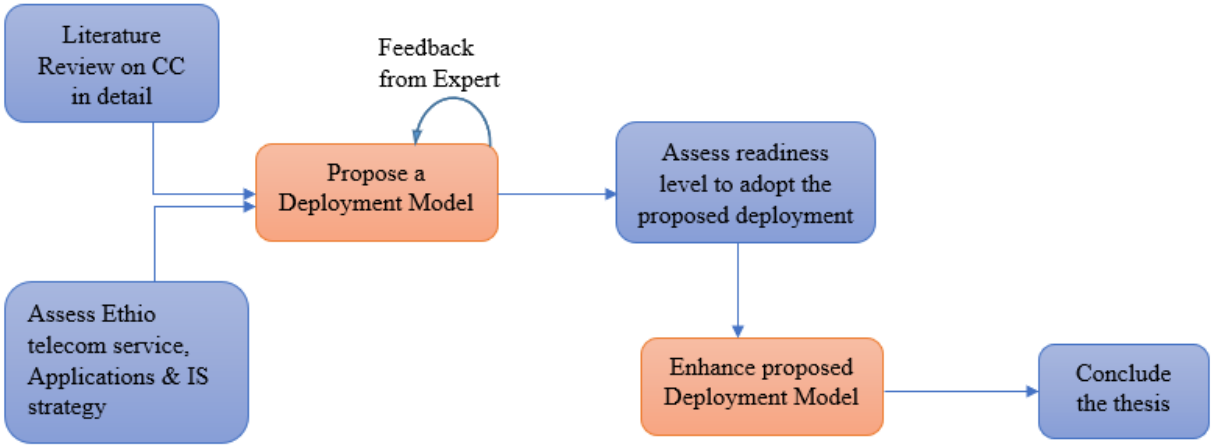


Figure 3.1. The Research steps

3.2.2. Research approach

There are three common research approaches: quantitative, qualitative, and mixed methods. Quantitative research applies a numerical approach to investigate the phenomena under study and to data analysis (Creswell, 2013). It is also the processes of collecting, analyzing, interpreting, and writing the results of a study and generates statistics using large-scale survey research, using methods such as questionnaires or structured interviews (Dawson, 2009). It is appropriate when there is a need to establish or confirm the relationships between different variables or objects (Leedy & Ormrod, 2005).

Qualitative approaches are developed in the social sciences to improve the understanding of social and cultural phenomena (Creswell, 2013). They are appropriate when there is a need to increase the richness of the data about a research problem (Bryman, 2004). The essence of qualitative research is to identify the characteristics and structure of phenomena and events examined in their natural context. Subsequently, these characteristics are brought together to form a mini theory or a conceptual model (Jan & Bartjan , 2010).

Mixed research methods involve the mixing of quantitative and qualitative approaches to obtain the advantages and eliminate the weaknesses of each approach (Creswell, 2013). Mixed-methods research can be conducted either in parallel, where the methods are applied at the same time, or sequentially, where the methods are implemented one after the other, this depends on the research objectives and questions (Saunders et al., 2009). The capability of a mixed-methods methodology capitalizes on the strength of both quantitative and qualitative methodologies by combining them into a single study. The adoption of a mixed-methods methodology involves both quantitative data analysis techniques such as statistical analysis and qualitative data analysis techniques such as thematic analysis for answering the research question (Creswell, 2013).

The mixed-methods approach were selected for this research since it gives a better understanding of and accurately reflects the problem under investigation by IS researchers as reported by Venkatesh and Brown (2013). This approach allows the researcher to obtain more evidence from various sources to study the research problem. This research approach was adopted from (Alemayehu, 2014,2015; Birhane, 2018; Stephen & Dan, 2016).

3.2.3. Research Strategy

A research strategy is a general plan that assists the researcher in solving the research questions in a systematic way (Saunders et al., 2009). There are many research strategies: experiment, survey, case study, action research, grounded theory, etc. (Creswell, 2013). The choice of the research strategy is influenced by the research questions, the research objectives and the philosophy that underpins the research (Saunders et al., 2009). Case research strategy is particularly well suited to IS research because the technology is relatively new and interest has shifted to organizational rather than technical issues (Benbasat, et al, 2002). Case studies, in their true essence, explore and investigate contemporary real-life phenomena through detailed contextual analysis of a limited number of events or conditions and their relationships (Zaidah, 2007).

A case study approach was selected for studying the Cloud Computing adoption framework for Ethio telecom for many reasons. The case study is a research strategy that allows the researcher to study a certain research problem in its real-life context and in its natural context (Robson, 2002; Runeson & Höst, 2009). Another advantage of the case study is the ability to gather information from specific entities (Noor, 2001) so the researcher can focus on a feature, issue, or unit of analysis (e.g. business unit). An additional advantage of the case study is the availability of multiple research methods for data collection such as interviews, observation and document analysis (Runeson & Höst, 2009), which gives the researcher the ability to explore the problem from different perspectives (Noor, 2001). The case study research can be designed as either single or multiple cases (Yin, 2009). In this research a single case or a case study was used as research strategy.

3.2.4. Sampling Design and Sampling Techniques

In conducting the quantitative research, designing a sample that reflects the theoretical population is critical for obtaining participants' responses to the developed questionnaire (Bell & Bryman 2007; Kotrlik & Higgins, 2001). The main purpose for this study is to propose a cloud computing deployment model that aligns with the specific need of Ethio telecom and to study the readiness level of Ethio telecom to implement the proposed Cloud Computing deployment model. Since Ethio telecom is large and has wide area coverage all over the country, participants for this survey was employees in the information system division in the Corporate Branch at head quarter.

3.2.4.1. Sampling Method

The sampling method was purposive. According to Given (2008), purposive sampling is virtually synonymous with qualitative research and it is about defining the population of eligible data sources, prior to selecting the actual sample. Determining which data sources meet the goal of purposive sampling for a qualitative study is equivalent to defining a set of eligibility requirements for the population. Besides, purposive sampling refers to a process where participants are selected because they meet criteria that have been predetermined by the researcher as relevant to addressing the research question. Hence, the source of the population was taken from the Information systems division. The respondents were selected based on their role in IT and the functions they performed within the process areas.

3.2.4.2. Population

The target population for this study was employee of Ethio telecom in information system division (ISD). In the information system division, there are around 410 employees where 1 chief information officer, 6 officer, 30 managers and the rest are staff.

3.2.4.3. Sample Size

The respondents for semi-structured interviews were experts and selected managers working in the ISD with the total number of five. For questionnaire, the actual sample size has been determined from total targeted populations through online calculator (sample size calculator using software)[1]. With 95% of confidence level and 8% of confidence interval (margin of error), the sample size is 110 which is 30 % of the total population which include managers, directors ,experts and staff.

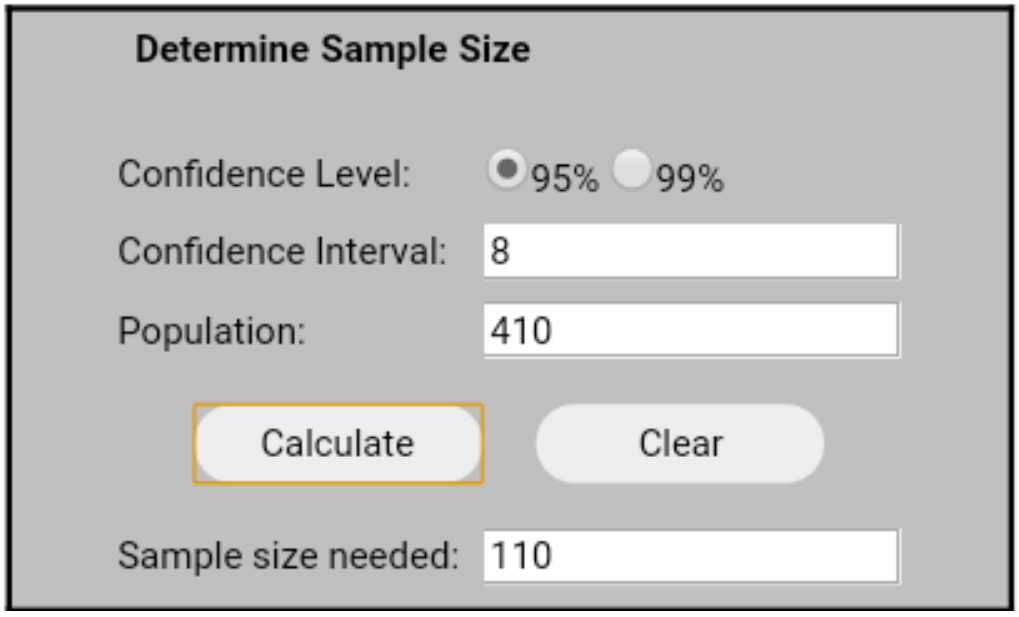


Figure 3. 2 Questioner sample size

3.3 Research Techniques

This section focuses on the data collection techniques, the logic linking the data to the proposition, and the criteria for interpreting the findings.

[1] (http://www.surveysystem.com/sscalc.htm), visited on 4/05/2020, 6:17PM.

3.3.1 Data collection

Data collection is a term used to describe a process of preparing and collecting research data. Data collection consists of either primary or secondary data. Primary data is information that is collected fresh by the researcher to answer current research questions. There are several methods of collecting primary data, it can be obtained either through observation or through direct communication with respondents in one form or another or through personal interviews (Alemayehu, 2014). Secondary data is the use of information already collected by someone else. Secondary data may either be published data or unpublished data, usually published data are available in various publications of the organizations, governments, researchers, individuals, and other sources of published information (Ruth, 2017). For this study interview, questionnaire and document analysis were used as a primary data source that contains close-ended questioners and semi-structured interviews.

3.3.1.1. Interview

According to Creswell (2013), interviews are well appropriate when looking for opinions, experiences, and privileged information from respondents in key positions. Semi-structured interviews were preferable for this study since it allows detailed discussions that enable controlling the scope of the study. The researcher prepared a semi-structured interview guide based on the objective of the study. The interviews were conducted in the interviewees' respective offices to keep their comfort. Before starting the interview process, the researcher contacts the selected candidates and give a brief introduction of the objective, scope and expected benefits of the study. During the interview process, the researcher takes a note. The notes were expanded, reviewed, and summarized immediately after each interview. After all interview processes were accomplished, the responses were organized and analyzed to summarize the required information for the study. Then the summarized ideas were compared with relevant and existing literature of the research.

3.3.1.2. Document Analysis

Document analysis was used to support the analysis by reviewing different documents of Ethio telecom. Some of the documents that will be analyzed include ISD strategy plans, Application documents, service type documents, IT infrastructure documents and related case study were reviewed.

3.3.1.3. Questionnaire

The development of the questionnaire is divided into three stages: item construction, questionnaire reviewing process and questionnaire testing stage (Moore and Benbasat (1991). In item construction stage, the constructors of the study will be identified or adopted from existing related studies that can provide similar measurement. The second stage is the reviewing process, which ensures the content validity of the questionnaire. Content validity is the process of ensuring that the items in the questionnaire represent their constructors (Saunders et al., 2009). This can be achieved by identifying the items carefully from the reviewed literature and experts' judgement (Saunders et al., 2009; Moore & Benbasat, 1991). The final stage is testing, where the questionnaire is tested before its final distribution (i.e. the pilot study). In this study the above stages were used. The questionnaire was distributed by using emails, and in-person to the respondents.

3.3.2 Data Analysis Technique

The data collected via questionnaires were analyzed by descriptive statistics analysis using SPSS version 20. Furthermore, (Creswell, 2013) suggested that qualitative research is fundamentally interpretative i.e. the researcher makes an interpretation of the data. A thematic analysis approach was applied to allow the researcher to report the findings of the study. This approach is used in qualitative research to identify, analyses and report patterns (themes) within data (Gale et al., 2013). Each theme represents something important about the data in relation to the research activities (Braun & Clarke, 2006). By classifying the data into categories through comparison between and within cases, the themes are developed and realized (Gale et al., 2013). The following steps were used in this research.

- **Familiarizations with the data**: This was achieved through the process of transcribing the interviews and reading the transcripts many times, and the participants checked the accuracy of the information.
- **Generating codes**: In this step, the transcripts are read to generate an initial list of ideas about elements that appear interesting. This step is helpful to ensure important aspects of the data are not missed (Gale et al., 2013).

- **Allocating themes**: Data was re-analyzed to group the codes together into categories or themes. Iteration may be required at this stage to review, define, and name the themes (Gale et al., 2013).
- **Producing the report**: The researcher produced the final report showing the findings and the full thematic analysis.

3.3.3 Pilot Testing

Both the questionnaire and interview were adapted from previous study. It is essential to make a pilot study to avoid misunderstanding in the questions and to make sure that no ambiguity and error on the questions so that the researcher would get accurate data from the target population. The questionnaire and interviews were pretested with some selected participant to identify redundant questions and missing questions. The participant gives a positive feedback for the pretested questions. A minor change was made to the questions and a final interviews and questioners was distributed to sample populations.

3.3.4 Validity and Reliability

To measure the quality of the research, both reliability and validity were maintained. Reliability is used to measure the consistency of the survey, whereas validity is used to measure the degree to which a scale or set of measures accurately represents the construct (Kothari, 2004). The following strategies were adopted to increase the study's validity and reliability and to decrease possible biases:

- Multiple methods survey (questionnaire, document analysis, and interview) for collecting the data of this research were used, which permit the researcher to achieve triangulation. Myers (2009) highlights that triangulation of data from different sources increases the quality of data, and accordingly the accuracy of the findings.
- The questionnaires were adopted from related studies. Modifications and adjustments were made with the advisor and a pilot test was made before distribution to the whole sample.
- Transcribed interview result was send to the participants of to verify them for accuracy and to review them for comments, amendment, and further feedback and clarification where necessary.

- For quantitative data, a Cronbach's alpha was used to measure the reliability of items of the questionnaire.

3.4 Readiness Assessment Method

In the literature, several researchers introduced methods to determine an organization's cloud readiness. They have used different methods for assessing readiness level from different perspectives. Loebbecke et al. (2011) presented the Magic Matrices method as a cloud readiness assessment tool based on the persuasion that an IT landscape in no larger company will be completely cloud ready. The method was consisting of three main steps which are identification, screening, and categorization. In this research, the researcher adopts Loebbecke's assessment tools for assessing readiness level of Ethio telecom to adopt the proposed model with some modification of the assessment methods to meet with the proposed Ethio telecom cloud deployment model.

The reasons for adoption of this method are, most of the cloud readiness assessment mostly is based on adoption theories and only assesses readiness for a cloud computing as a general not specific to a cloud deployment model, since each cloud deployment model has a different value proposition and different factors associated with it (Rountree & Castrillo, 2013). Using this method identifies which application or service are ready to specific cloud computing model and factors or constraints for application or service to move to specific cloud model. It is also simple since it does not need any statistical analysis. The details of each phases followed in this research will be discussed below.

1) **Identification: T**he identification phase has two major tasks. The first task is to identify the service or application to be investigated for the cloud readiness by using open ended questioners. The second task will be to identify the cloud-readiness criteria to be relevant to the proposed model from a literature and adopting from the Loebbecke's readiness assessment criteria.
2) **Screening:** This phase also has two tasks. First, all identified service or application are evaluated against all cloud readiness criteria for each IT service or applications. Some selected IT Directors, managers, experts, and employee will evaluate each service using a close ended questioner. The gathered questioner will be converted to Magic Matrix format for evaluation of cloud readiness. The second task will be to determine which criteria are

likely blocks for IT services to be ready for the proposed cloud model both individually and overall. The researcher uses a Gartner magic matrix for evaluating the cloud readiness.

A Gartner Magic Quadrants is a research methodology and visualization tool for monitoring and evaluating the progress and positions of companies in a specific, technology-based market (Gartner ,n.d). Magic Quadrants research reports can be highly useful tools for investors looking to find a company that fits their needs and businesses seeking to compare competitors in their market and possibly gain the upper hand (Hill et.al, 2009). According to Gartner ,n.d, Gartner magic quadrant has four categories namely challengers, leaders, niche players and visionaries. Niche players are successfully focused on a small segment or are unfocused and do not innovate or perform better than others. They have low scores both on completeness of vision and the ability to execute (Gartner ,n.d). Visionaries understand where the market is going or have a vision for changing market rules but are not executing them properly. They are aware of how the market evolves and can be potentially innovative but might not be able to execute these visions (Gartner ,n.d). Challengers are performing well today or can dominate a large segment, but do not show insight into the market. They have ability to execute but might lack a strong vision (Gartner ,n.d). Leaders perform well in terms of their current vision and are well positioned for the future. They score high on both completeness of vision and the ability to execute (Gartner ,n.d). The below figure illustrates Gartner magic quadrants categories.

Figure 2.6 Gartner Magic Quadrants (Gartner ,n.d)

3) **Categorization**: The objective of the categorization phase is to designate the IT services or application under consideration as “likely cloud ready” or “not cloud ready” based on the cloud readiness evaluation for each IT service or application result generated in the screening phase.

3.5 Chapter Summary

In a research, research design and methodology are crucial, in that its services as a bridge between the initial research question to the data to be collected and conclusions to be drawn. This chapter has presented details of research approach and strategy, the reason for selecting these strategies and approaches and the sampling methods and sample size and methods. It also presented the research techniques like data collection method and data analysis methods. Finally, a cloud deployment model selection criteria and readiness assessment method used in this study are discussed. The next chapter discusses a cloud computing model for Ethio telecom.

CHAPTER FOUR
ETHIO TELECOM CLOUD DEPLOYMENT MODEL

4.1 Overview

This chapter provides a Cloud deployment model suitable for the case company. The chapter is divided into different major sections. The first section presents the results of document analysis with Ethio telecom infrastructure and service which includes description of basic service, business and mission critical system, existing infrastructure, and customer. Then it will present the challenges of current infrastructure from the interview results. Second, Evaluation of different cloud deployment model alternatives will be conducted with the criteria to select a best fit Cloud model. Finally, a cloud computing deployment model will be proposed for the case company and evaluated by domain experts.

4.2 Data collection

To identify Ethio Telecom cloud computing needs and to propose a cloud computing deployment model that aligns with the specific needs of Ethio telecom a document analysis and interview was conducted. The researcher analyzed different Ethio telecom applications LLD documents (MVaS, ISP, IPCC,CRM), Website and internal portals, and a datacenter document for understanding ethiotelecom vision, mission, business and mission critical systems, infrastructure, and services. Related case research is also reviewed for assessing factors needs to be considered for selecting a cloud deployment model.

An interview was also conducted with five domain experts to identify both the needs and challenges of current infrastructure in Ethio telecom. The participant were experts from IT technical management and IT infrastructure management groups. The interview result was transcribed and sent to the participants of to verify for accuracy and to review them for comments and feedback before starting the analysis. The proposed cloud deployment model was evaluated by four domain experts and the feedback was amended and a final model was proposed. The next section presents the both the document analysis and interview results.

4.3 Ethio telecom Infrastructure and Services

In this sections Ethio telecom basic service offered to customer, a mission and business critical systems, Existing infrastructure ,policy and procedures, and a type of customer are presented.

4.3.1. Basic service

Ethio telecom service are categories into three major domains, which are fixed line, mobile and internet service (Ethio telecom, n.d.-d). A fixed line service includes fixed line phone, Fixed Wireless CDMA, Fixed Line Value Added Service (VAS) and ISDN (Integrated services digital network),Mobile service includes GSM Mobile, WCDMA Mobile Roaming service Satellite mobile telephone and Internet service includes broadband internet, EVDO (Ethio telecom, n.d.-d). The following are descriptions of Ethio telecoms basic service.

- Hybrid SIM account service enables customers to use both prepaid and postpaid payment plans with a single SIM card. This enables customers to minimize call interruptions caused by prepaid or postpaid account balance used up, manage account balance, and avoid bill-shock problems.
- **VSAT:** (Very Small Aperture Terminal) is an internet or VPN service using a satellite access mechanism. It is a way of establishing private satellite communication networks for large organizations that have widely dispersed locations. Ethio offers VSAT service that is provided through Broadband VSAT. It can also support Voice services in addition to internet and data. This service is cost-effective, accessibility availability, reliability and work even on the remote areas
- **Virtual Private Network (VPN)** enables private and public institutions to connect with their various branches and to establish their own private networks. The service is available all over Ethiopia in areas covered by Ethio telecom terrestrial and mobile network that support data services enables you to share information and activate all information technology systems inside your branches via fixed and mobile options.
    - ✓ **Fixed Broadband VPN** uses wired or fixed wireless options to connect branches. Ethio telecom gives VPN service mainly through MPLS (Multi-Protocol Label Switch), the most cost-effective way to have a secured connection between different sites/branches of an organization.

- ✓ **Mobile Broadband VPN** service VPN is an extension of Virtual Private Network (VPN) to the mobile broadband access mechanism. The service is provided through 4G, 3G & EVDO options. It allows people or branches to access the LAN environment in a secure and simple manner while away from the office environment. Each connection is defined by a unique, private Access Point Name (APN).

- **Fixed Wireless Broadband** : Fixed wireless is a broadband internet service with wireless access but fixed in each location. Fixed wireless broadband signals are broadcasted from a wireless base station to a receiver. The receiver is usually a fixed aerial, antenna, or dish device which you mount on your building in a similar manner to a satellite dish. Ethio telecom currently provides the service with Aironet. It works up to 40 KM away from a fixed network.
- **M2M**: Business Solution Machine to Machine is a wireless technology that enables machines to talk to each other and which you can access directly from your office's or home's computer. Ethio presents to your business M2M solution which can be applied in a wide range of industries fleet management and cargo trucking , Banking POS materials, Tax- cash registration machine, Health–Telemedicine ,and Hotel and Home security system. Ethio telecom's M2M business solutions enable you to manage your assets, reduce your cost, boost your productivity, improve your company's image and real-time tracking.
- Fax is the telephone transmission of scanned-in printed material (text or images), usually to a telephone number associated with a printer or other output device. The original document is scanned with a fax machine, which treats the contents (text or images) as a single fixed graphic image, converting it into a bitmap. In this digital form, the information will be transmitted as an electrical signal through the telephone system. The receiving fax machine reconverts the coded image and prints a paper copy of the document.
- **Fixed Wireless CDMA** It is like the ordinary fixed telephone service. You can get the service using a fixed wireless terminal (FWT) which enables you to get voice, data, and other value-added services. It works wherever a CDMA network is available.
- **Fixed Line Service**: The service is a provision of the Fixed Line–Next Generation Network (FL_NGN) service with a pre-paid tariff plan which helps you to manage your telephone

bill budget and avoid unnecessary bill settlement hassle, and service with a postpaid tariff plan. Customers settle the bill monthly.

- **Public IP Address :** Every device connected to the public Internet has an assigned unique number known as an Internet Protocol (IP) address. Public IP Addresses (also known as Static IP Addresses) are IP addresses that are visible to the public. It helps customers to be accessed from the World Wide Web(WWW) over the Internet.
- **Mobile Internet** enables your mobile phone, tablet, or mobile broadband modem to access the Internet while you are moving. It works both on 2G mobile (GPRS) and 3G Mobile.
- **EVDO** is a Broadband mobile Internet service with high speed using CDMA technology. The service works wherever a CDMA network is available. The service is available in Addis Ababa and more than 200 cities and towns throughout the country. It is provided in three alternative packages: 1GB, 2GB and 4GB for both prepaid and postpaid customers.
- **Fixed Broadband Internet** service is an Internet service with wired access. It can be provided through copper or fiber depending on the speed requested and other factors. Ethio provides this service in two options, Limited Fixed Broadband Internet is a packaged service based on volume, mainly targeting residential customers and Unlimited Fixed Broadband Internet, it is unlimited in volume and sold with a fixed monthly rent with different access speed options.
- **Roaming service** enables mobile users to automatically make and receive voice calls, send, and receive SMS as well as access internet service while traveling outside the geographical coverage area of their own home network by using a visited network. Currently, Ethio telecom international roaming service is only available for postpaid customers.
- **Postpaid Mobile service**: Ethio telecom introduced post-paid services with the latest technology (GSM, CDMA, WCDMA and 4G/LTE) which enables customers to get more options, advantages, and solutions to do their work easily. Postpaid customers are billed according to their use of mobile services at the end of each month.
- **Pre-paid mobile service** is a normal mobile service offered through Ethio telecom's SIM card. To get the service, the customer must pay for the talk time and for other services in advance. You need to regularly recharge it with recharge scratchable cards. Each recharge balance has a denominated validity period.

- **Web hosting service**: It is a hosting service that allows individuals and organizations to make their own website accessible via the world wide web. The main purpose of web hosting is providing the customers with a server space on which they can store their files. Ethio telecom presents to businesses a web hosting service to be accessed on the Internet.
- **VAS** - value added service in addition to the main service that includes call divert, call conference, credit transfer, Voice short message service, call waiting, voice mail, miss call notification and package gifts.
- Other services which are business mobile, a bundled postpaid mobile service that allows all postpaid mobile customers to make calls at a discounted rate.

4.3.2. Business and mission critical systems

A mission critical system is a system that is essential to the survival of a business or organization, when they are fail or interrupted, business operations are significantly impacted (Ian, 2008). Business critical systems whose failure may result in very high costs for the business using that system (Ian, 2008). In the following section Business and mission critical systems of Ethio telecom presented.

- **Converged Billing System (CBS)** is a solution in the telecommunication industry that enables common management of all users and all service charges onto a single customer invoice and a unified view of customers. Ethio telecom is using Huawei's CBS system designed for post-paid and pre-paid billing for convergent wireless/fixed networks, this robust billing engine provides rating and billing of multi-play voice, content, internet, VoIP, IP, e-commerce. It also supports the growing complexity associated with value added services for wireless (GSM/GPRS, CDMA, LTE) and fixed-line networks.
- **Customers relation Management (CRM)** is an approach to manage a company's interaction with current and potential customers. It uses data analysis about customers' history with a company to improve business relationships with customers, specifically focusing on customer retention and ultimately driving sales growth **(**Chen & Popovich , 2003). Ethio telecom is using an operational CRM which is made up of three main components, a sales force automation, marketing automation, and service automation. The sales force automation works with all stages in the sales cycle, from initially entering contact information to converting a prospective client into an actual client. Marketing

automation focuses on easing the overall marketing process to make it more effective and efficient with a goal to turn a sales lead into a full customer. Through service automation, customers are supported through multiple channels such as phone, email, knowledge bases.

- **IP Contact Center (IPCC)** is a contact center that does not use a circuit switching. All calls are IP or converted from PSTN to IP. Ethio telecom uses a private cloud IPCC which is a desktop cloud computing. This system enables Ethio telecom to significantly improve customer service efficiency and quality, reduce operating costs, enhance the attractiveness of self-service, release the potential of agents, and transform to marketing centers and value centers (Lily, 2017).
- **Mobile value-added services (MVAS)** refer to all user-paid, value-added services excluding traditional voice communications services (Wang & Lin ,2012). This is a basic application for a mobile customer of Ethio telecom it cover a wide variety of services or applications such as SMS chatting and dating premium services, message services, ringtone downloads, electronic transactions, Missed call alerts and voicemail box, mobile advertising, Infotainment services and they are provided by using USSD,SMS or Voice.
- **The enterprise resource planning (ERP) system** incorporates a set of programs that provides support for main organizational activities such as manufacturing and logistics, finance and accounting, sales and marketing, and human resource(Aladwani, 2001). It also helps for sharing of data and knowledge among different parts of the organization as well as reducing costs, and improves management of business processes (Aladwani, 2001). Currently, Ethio telecom is using Oracle ERP with four modules that currently functional areas in the company are inventory management, human resource management, accounting, and financial modules.
- **Ethio-mail** is an office automation system integrated with Ethio Telecom Company's Intranet Enterprise system that provides email service for the company's employee. Every day-to-day activity of the company is supported by email. This system makes easier communication throughout the company and dramatically reduces paper or letter circulation. Among the benefits of outlook emails, every division, department, Region, chief officer, director's, managers, supervisor, staff, and various support groups makes fast communication and transfer of messages easily throughout the company email service. Ethio telecom uses a Microsoft exchange server for email service in the company.

- **Electronic customer accusation form(Ecaf):** Ecaf is a system that is integrated with CRM to store a paper accusation form in electronic way and other support system like Etopup, Ethio clinic, change management system, caller ring back tone (CRBT),business intelligence core platform(BICP),call center attendance system.

4.3.3. Ethio telecom Datacenter

A Data Center (DC) is a pool of computing resources clustered together using communication networks to host applications and store data (Kliazovich *et al.* 2012). Ethio telecom data centers use three-tire model or Cisco hierarchical model with three layers design which are core layer, aggregation layer and access layer. Three-tier data center architecture is a hierarchical tree-based structure consisting of three layers of switching and routing elements having enterprise-class high-end equipment in higher layers of hierarchy (Kliazovich *et al.* 2012). A three-tier DCN architecture is shown in Figure 4.1 with its layers. Ethio telecom has five data centers namely Legehar, Kirkos, Nifas silk, Bole and Arad sites. Each site is using a star topology, this makes the data center redundant and online. Almost applications and services are run for these sites. A disaster recovery site located at mekkele is used as backup in case some failure happens in all data centers.

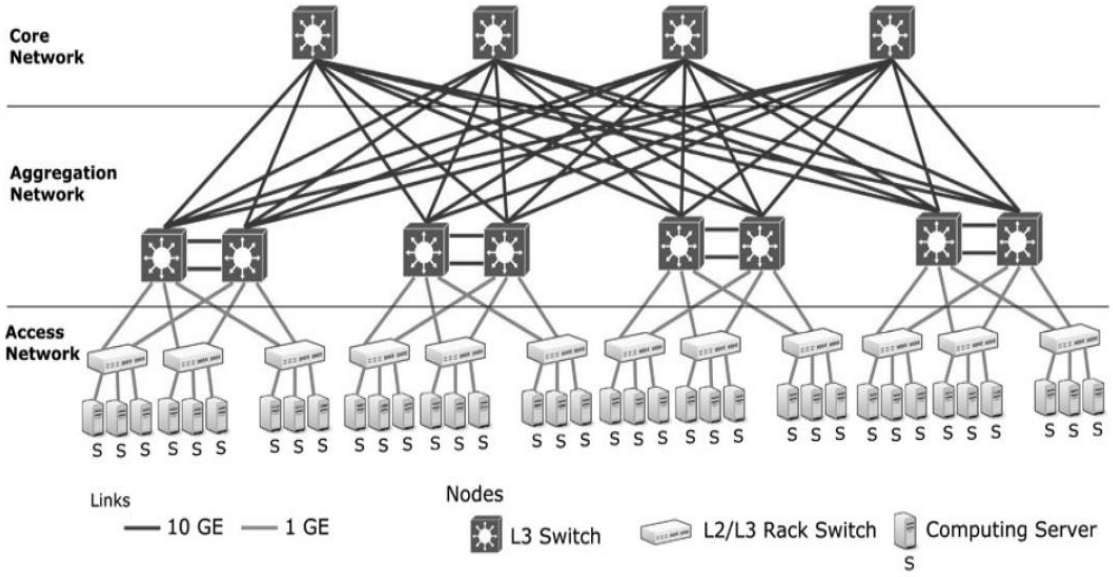


Figure 4.1. Three-tier Data Center Architecture (Kliazovich *et al.* 2012)

4.3.4. Ethio telecom Customers

Since Ethio telecom is a sole telecom service provider, almost every telecom service user in Ethiopia is an Ethio telecom customer. Ethio telecom categories its customer's as residential and enterprise customers. Residential customers are individual with a basic mobile, fixed line, and data users while enterprise customers are organization with different service users. They can be governmental or non-governmental organizations. Ethio telecom provides service for individuals, households, government organizations, business organizations, public institutions (schools, hearth centers, universities & others) and to different companies, private organizations, embassy, and international organizations.

4.3.5. Challenges of current Infrastructures

Information technology infrastructure is a strategic combination of hardware, software and other resources and services needed to host IT workload for the efficient deployment, operation, and management of IT environments in an organization. From small businesses to enterprises, all organizations have IT challenges. In this section the main challenges of current IT infrastructure in Ethio telecom is presented.

An interview was conducted with five domain experts to identify any issues or challenges of current infrastructure in Ethio telecom. The participants outlined some challenges regarding current infrastructure in their organization.

- **DC Management issues :** In a data center there are applications, connecting cables, network connectivity, cooling systems, power distribution, storage units, and much more running all at once and managing all this resource were difficult. Some participants stated that "*there are many servers in our data center, this makes it difficult to manage it* " (P1, P3). Other participants indicate that different servers use different management and maintenance tools which make it difficult to monitor (P3).
- **Storage :** Some participants indicated that "*Some of the application does not have a backup example ERP and Mail servers*" (P2, P3). This applications are the basic application in which the organization is running in day to day activates what happens if these servers become crashed, power outages or a natural disaster happen, all these issues present a serious risk to the business.

- **Outdated technology:** One participant stated that "*the services are not enough to achieve the organization mission and vision because most of the infrastructure are old* "(P3). Other participants indicate the company procurement process is slow to buy new technologies (P5). This prevents the businesses to remain modern and regularly up to date with the latest technology.
- **Lack of Resource utilization:** Some participants indicated that the current infrastructure lacks resource utilization. One participant stated that "*there are many servers in data centers some of them are working with high traffic while others are not working*" (P4). Most services in the data center avoid downtimes, this results in wastage of resource and space.
- **Reduced agility**: The ability to scale up or down can be critical for a business to stay agile and competitive. One participant stated that "*some applications are designed to serve limited users or sections now they are serving over capacity. This led to performance issues*" (P3). This local server may fit the organization needs for now but not when there is a scale up as demand increases.
- **Security** : Some of the participants indicate that there is a security concern. One participant indicated that "*due to a security problem some of our systems attacked repeatedly like mail severs"* (P5). Another participant also indicated that the degree of automation is poor when compared to current technology and this makes us vulnerable to security attacks (P1).

DC management issues, storage, outdated technology, lack of resource utilization ,reduced agility and security threat are the main challenges of current infrastructure in Ethio telecom. Most of the respondents indicated that the degree of automation in their organization is very poor. One participant stated that "*the degree of automation is poor when compared to current technology* " (P1). Other participants also stated that "*it is poor it can serve the company with its full capacity if the current problems are solved"*(P3).

All the respondents recommend their solution for solving the limitation of the current service. One participant stated that *"I recommend using virtualization for resource utilization and increasing performance and using uniform management tools to monitor the services*" (P3). Another respondent recommended to use new advanced technology that can be updated and easily monitored (P1). This indicates that newer or updated technologies can solve the current

infrastructure problems. Most of the respondents indicate that cloud computing can solve the current infrastructure problems. One participant indicated that "*cloud computing can solve all this problem since it is new technology* " (P3). However, others indicated that cloud computing can solve most of the challenges but not all the challenges at least it can improve the current infrastructure to give a better performance.

To understand current infrastructure challenges in Ethio telecom, an interview was conducted with five domain experts. The analysis of the data shows that DC management issues, storage issues, outdated technology, lack of resource utilization, reduced agility and security threats are the main challenges of current infrastructure. From these challenges a business requirement can be drawn to solve current infrastructure challenges and an input for model design. The business requirements include easily managed DC ,flexible storage, update technology, resource utilization, business agility and low security risk. For a potential cloud deployment model to fulfill all the business requirements in an equally complete manner, will obviously be challenging. Therefore, the selection of a new cloud model is grounded by a model which will fulfill most of the business requirements.

4.5 Evaluation of Cloud Deployment Alternatives

This section describes a choice of deployment model for Ethio telecom. It starts with the evaluation of the cloud alternatives applicable to Ethio telecom. The selection of the cloud model in this paper were grounded by comparison of the advantages and challenges of each possible model for the case company. Private Cloud, public Cloud and hybrid Cloud will be evaluated as a best possible alternative for the case company. A community cloud was not included in the comparison because a community cloud is provisioned for exclusive use by specific communities of consumers that share a common concern like mission, security requirement policy and compliance consideration (Rountree & Castrillo, 2013). The infrastructure and computational resources are exclusive to two or more organizations that have common privacy, security, and regulatory considerations, rather than a single organization(Rountree & Castrillo, 2013; Narayana et.al , 2017). Since the case company is the only telecom service provider in Ethiopian and there is no other organization that shares a common mission or security requirement with Ethio telecom. The evaluation of each cloud deployment model follows the levels of (low - medium - high). The results of the evaluation for each cloud deployment model were summarized into tables.

4.5.1. Public cloud

The cloud infrastructure is provisioned for open use by the public and it may be owned, managed, and operated by a business, academic, or government organization, or some combination of them (Mell & Grance, 2011). It exists on the premises of the cloud provider and the cloud provider has full control over the resource and application so the degree of organization to control and to own the cloud is low. Public clouds offer the most savings in terms of upfront costs and organizations do not worry about spending money for initial hardware and software deployments (Rountree & Castrillo, 2013). Public cloud services use a pay-as-you-go charging model whereby the consumer will pay for what they use (Chandrasekaran, 2015; Rountree & Castrillo, 2013; Karandeep, 2016). There is no cost of set-up involved, no capital investment which makes it cost efficient. So, cost efficiency is very high. In terms of security public cloud is less secure (Karandeep, 2016). This is because the public cloud is offered by a third party and they have full control over the cloud. It is less secure compared to private and hybrid cloud (Narayana et.al ,2017; Chandrasekaran, 2015; Rountree & Castrillo, 2013). In public cloud privacy and security is a concern so it is low.

Any cloud service provider faces a major risk in the form of reliability of the services (Karandeep, 2016). A public cloud is less reliable compared to private cloud, it depends on the service provider availability and internet connection (Narayana et.al ,2017; Karandeep, 2016). Data and application integration are easier in public clouds as it uses only one type of platform and portability is very easy (Karandeep, 2016; Narayana et.al, 2017). The public cloud is highly scalable (Narayana et.al , 2017). The resources in the public cloud are large in number and the service providers make sure that all the requests are granted (Karandeep, 2016, Chandrasekaran, 2015, Rountree & Castrillo, 2013). In terms of performance a public cloud can vary from low to medium because performance depends on the network and resource (Chandrasekaran, 2015). The service provider must adequately manage the resources and the network (Karandeep, 2016). As the number of users increases, it is a challenging task for the service providers to give good performance (Karandeep, 2016). Public clouds are more appropriate for organizations that do not have the resources to ensure high availability of on-premises systems and for workloads that require access to high volume data (e.g., real-time analytics running against very large data stores)(CSCC, 2014; CSCC, 2017a).

In terms of fulfilling business requirements, public cloud was partly fulfilling on easily managed DC since the DC is located on premises of cloud providers and managed by them. Only the

migrated services are managed by cloud providers while reducing the load on managing on-premises DC partially. Public cloud also increases business agility because any request from a user can be handled by the cloud providers, so it fulfills business agility. A public cloud also used as a disaster recovery site for some enterprises it can solve storage issues and since it is a new technology, it can update the old technology in the current datacenter but may face a new cost to the company. So, in terms of storage and updated technology public cloud fulfill. However, in terms of security and resource utilization public cloud does not fulfill because the cloud is monitored and controlled by the cloud providers this can increase the risk of attack from a third party. In terms of resources utilization , Public cloud is not fulfilling business needs because the data center is built from the provider own cost which does not consider the existing resource in the datacenter.

4.5.2. Private cloud

The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers like business units (Mell & Grance, 2011). This cloud model is implemented in a single organization and available to limited users in the organization, its resources and applications are controlled by the organisations itself (Khurana & Verma, 2013). The organization have full control over the resource and application so the degree of organization to control and to own the cloud is High. Implementing a private cloud requires a higher upfront cost, the cost of purchasing equipment, software, and staffing results in additional cost of set-up to an organization to have their own private cloud (Chandrasekaran, 2015). One of the reasons for additional cost is that an organization implements an infrastructure not only to support current needs but also the future needs as well which is cost inefficient (Rountree & Castrillo, 2013). In terms of security and privacy, private cloud models have low risks. There is a risk in every type of service model, but a private cloud has the least risk (Chandrasekaran, 2015). With a private cloud implementation, an organization has complete control over the systems, applications, data, can control who has access to what, and perform security and compliance audits (Rountree & Castrillo, 2013; Chandrasekaran, 2015).

The performance of a cloud delivery model primarily depends on the network and resources (Chandrasekaran, 2015). Since the networks are managed internally, the performance can be controlled by the organization. Private clouds on the other hand, invest in the equipment’s and

other resources because of their mission-critical needs as well as the security concerns (Karandeep, 2016). So, this model has a higher performance. A private cloud is more reliable, since all the service providing equipment, set-up and data is within the organization (Karandeep, 2016). Resources like servers and networks are hosted internally, the creation of virtualized operating environments means that the network is more resilient to individual failures across the physical Infrastructure (Chandrasekaran, 2015). Data and application integration are easier in private clouds as it uses only one type of platform and portability is very easy (Karandeep, 2016). Private cloud both on-site and outsourced are best suit for a mission critical and security-sensitive services with a very stringent latency requirement for business continuity (CSCC, 2014; CSCC, 2017a). The private clouds offer limited scalability as it is owned by the organization itself and again is restricted by the price it can pay for the infrastructure (Karandeep, 2016).

A Private cloud is managed and controlled by the organization any security risk is mitigated by the organization itself. A private cloud deployment also considers the current resource in the DC for upgrading or using it as a part of a cloud resource with increased resource sharing. So, in terms of addressing security, storage, updated technology and resource utilization, a private cloud can fulfill. In other cases, the sharing of resources reduced the number of cooling systems, power distribution, storage units used for dedicated application or service by some means. So, in terms of DC management private clouds partly fulfill. But a private cloud is not allowed expecting that the cloud model can increase or reduce its performance, resources, and functionalities according to the user's needs.

4.5.3. Hybrid cloud

The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds)(Rountree & Castrillo, 2013). In a hybrid cloud, the resources are managed and provided either in-house or by external providers (Narayana et.al, 2017). Hybrid cloud models can be implemented in three ways, a separate cloud provider team to provide both private and public service, a complete hybrid package cloud provider and organization who manage their private clouds themselves sign up to a public cloud service which they then integrate into their infrastructure (Narayana et.al, 2017). The degree of organization to control and to own

the cloud is medium because it depends on the way the cloud is implemented. The hybrid cloud offers a medium level of cost efficiency , as the more expensive services can always be used from the public cloud platform and the rest can be deployed as a private cloud in the enterprise (Chandrasekaran, 2015; Karandeep, 2016). Hybrid cloud usually is a combination of public and private cloud (Chandrasekaran ,2015). The private cloud is secured, but as the hybrid cloud also uses the public cloud, there is high risk of security breach. Thus, it cannot be fully termed as secure but as partially secure (Rountree & Castrillo, 2013; Sumit, 2014; Chandrasekaran, 2015; Narayana et.al, 2017).

Hybrid clouds can provide high scalability as they can move to public clouds when the demand arises (Karandeep, 2016). The main reason for having a hybrid cloud is to use the property of a public cloud with a private cloud environment (Chandrasekaran ,2015). Hybrid clouds provide a medium level of reliability as they combine the features of both public and private clouds as the most accessed data is kept within the organization (Karandeep, 2016). Hybrid cloud faces difficulties in data and application integration as it combines both public and private platform features (Karandeep, 2016; Narayana et.al, 2017; Rountree & Castrillo, 2013). Due to the compatibility issues among the different cloud environments, the hybrid cloud infrastructure is less portable than the other models. In terms of performance hybrid cloud is moderate since the private environment is maintained with access to the public cloud whenever required (Chandrasekaran, 2015). Hybrid deployments help take advantage of public cloud features for certain non-critical workloads, while retaining business critical data and applications on-premise with a cloud bursting ability to extend computing capabilities (CSCC, 2014; CSCC, 2017a).

As compared to the private and public cloud deployment model a hybrid cloud encompasses the best and worst of both cloud models. In terms of addressing business needs hybrid cloud is partly fulfilled on easily managed DC ,flexible storage, resource utilization ,business agility and security threat while fully fulfilling upgrading of old technologies. In hybrid cloud the organization has control over private cloud but not to the public the public cloud, this makes the organization limited to monitor the cloud fully. With the private cloud capability in hybrid cloud the organization can use the existing resource in the DC for upgrading or using it as a part of cloud resource with increased resource sharing. A hybrid cloud allows expectation that the cloud model can increase or reduce its performance, resources, and functionalities according to user's needs.

4.6 Cloud Deployment Model Selection

In the previous section, three cloud deployment models were evaluated against the factors that need to be considered for cloud model selection and a business need. The evaluation results of the cloud deployment models are combined into the table to show the comparison of the cloud deployment models and select the best suitable cloud deployment model for the case company. The evaluation results are summarized in Table 4.5 below.

		CLOUD DEPLOYMENT MODELS		
		PUBLIC CLOUD	**PRIVATE CLOUD**	**HYBRID CLOUD**
Business needs	1. Easily Managed DC 2. Flexible Storage 3. Update technology 4. Resource utilization 5. Business agility 6. Low security risk	1. Partly fulfill 2. Fulfill 3. Fulfill 4. Not fulfill 5. Fulfill 6. Not fulfill	1. Fulfill 2. Fulfill 3. Fulfill 4. Fulfill 5. Partly fulfill 6. Fulfill	1. Partly fulfill 2. Partly fulfill 3. Fulfill 4. Partly fulfill 5. Fulfill 6. Partly fulfill
Factors to be considered	Cost Efficiency	**High**	**Low**	**Medium**
	Privacy and security	**Low**	**High**	**Medium**
	Data & Application Integration	**High**	**High**	**Low**
	Scalability	**High**	**Medium**	**High**
	Performance	**Medium**	**High**	**Medium**
	Reliability	**Low**	**High**	**Medium**
	Portability	**High**	**High**	**Low**
	Ownership and user control	**Low**	**High**	**Medium**
	Criticality of cloud service and types of workload	**Low**	**High**	**Medium**
		Choices 3	**Choices 1**	**Choices 2**

Table 4.1. Comparison of the cloud deployment models.

The selection among the three cloud deployment models, namely Public Cloud, Private Cloud and Hybrid Cloud, was based on the combination of two prioritized criteria. These criteria are the

ability of the cloud model to address or fulfill a business needs and the level of cloud model to meet the factors to select a cloud deployment model.

First, the Public cloud has the worst evaluation result in terms of the ability of the cloud model to address or fulfill a business need. It addresses flexible storage, updates technology and business agility. While DC management issues, lack of resource utilization, Storage issues and security threats are partially addressed by the public cloud. On the other hand, the level of cloud model to meet some factors to select a cloud deployment model is medium but some of them are low. With reduced cost, data & application integration, scalability, and portability are high while privacy and security, reliability, ownership, user control and criticality of cloud service and types of workload are low. So, Public cloud model was not best fit model for Ethio telecom because of risk associated with the privacy and security limit the use of the public cloud model by Ethio telecom, as only non-sensitive or low-sensitive data might be used in this deployment model and the company policy is not allow to store data out of Ethio telecom premises. Additionally, the cloud model is owned and controlled by the cloud provider.

Second, the Private cloud deployment model has a good evaluation in terms of both the ability of the cloud model to address business needs and the level of cloud model to meet the factors to select a cloud deployment model. From the business needs, business agility was not fulfilled by the private cloud model since it cannot increase or reduce its performance, resources, and functionalities according to the user's needs. The initial setup cost was also very high for private cloud. As compared to other deployment models a private cloud has a better chance to best fit Ethio telecom needs. But the agility of the service can be improved by considering a future expansion of service and budgeting a cost needed for this service when implementing a private cloud to the organization.

Thirdly, Hybrid cloud deployment model has the medium evaluation results which partly fulfills in terms of the ability of the cloud models to address business needs. It addresses outdated technology and improves business agility while easily managed DC, resource utilization and low security risk are not fully addressed by Hybrid cloud. Since the Hybrid cloud model represents a heterogeneous environment, management of the multiple cloud environments becomes a complex task for the organization. Additionally, the integration of application and data with several cloud

environments requires a lot of efforts and expertise. Thus, the Hybrid Cloud deployment might be the second choice for Ethio telecom.

Summing up, three cloud deployment models were compared and proposed as a possible best fit deployment model in the following order. First choice would be the Private Cloud deployment model, the second choice would be the Hybrid Cloud deployment model, and the third choice would be the Public Cloud deployment model. However, considering the options of the case company realistically and the best suitable cloud deployment model for the case company could be a private cloud (on-premises) with integration of existing infrastructure. This model combines the benefits of private cloud models and existing infrastructure. But requires fewer efforts for the deployment, integration and management compare to the other cloud deployment model.

4.7 Proposed Deployment Model

In the previous section the evaluation results of the cloud deployment model were presented. Based on the ability of the cloud model to address or fulfill a business needs and the level of cloud model to meet the factors to select a cloud deployment model, a private cloud model was selected as the first selection to best fit the case company. In this section the proposed cloud deployment model with its components and feedback from the experts were presented.

A private cloud deployment model was proposed based on analyzing and considering the interview held with domain experts to understand current infrastructure challenges or business requirements includes easily managed DC ,flexible storage, update technology, resource utilization, business agility and low security risk. The level of cloud model to meet the factors which are identified from literature to select a cloud deployment model, security, and data protection policy of the case company.

Private cloud model provides cloud services to a private organization. It may be managed by the organization itself or a cloud provider either on-premises or off-premises. The cloud computing architecture can overcomes many problems with traditional client-server architecture, such as poor scalability, and low performance (Laili et. al,2013). Cloud computing can not only improve server utilization and provide high-performance computing and mass data storage, but also reuse the old IT resources to reduce budgets (Caifeng et,al,2013). The researcher proposed a private cloud (on-

premises) deployment model. The following figure shows the general layout of proposed private cloud model.

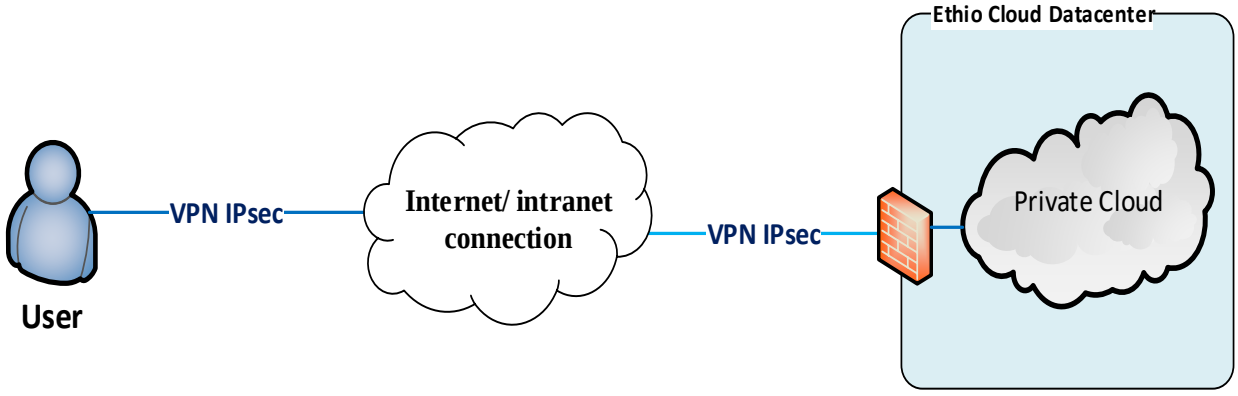


Figure 4.2. Proposed cloud deployment model

As shown from the figure this model includes different components to address business needs of the case company. The components are private cloud(on-premises), different firewalls, VPN's, and users. The description of each component presented below.

- **User:** Ethio telecom employees in all divisions and some customers are the user of this systems. They can operate or request a service from any of the regions, zones or sales shops by using portal or custom UI or API over VPN internet or intranet connection, they use this feature provides a secure access to their service request to the data center.
- **VPN** (Virtual Private Network) technology provides a way of protecting information being transmitted over the Internet, by allowing users to establish a virtual private "tunnel" to securely enter an internal network, accessing resources, data and communications via an insecure network such as the Internet (Judith,2015). VPN implemented with help of IP security (IPSec) can make a VPN as a standard way of implementing it. The IPSec and VPN have been revised and well established in this way to provide the robust security standard with acceptable data confidentiality, authentication, and access control regardless of the transmission medium (Judith,2015). So, in this model VPN with IPSec will be used.
- **Next-generation Firewall (NGFW)** is a part of the third generation of firewall technology, combining a traditional firewall with other network device filtering functions such as an application firewall using in-line deep packet inspections (DPI), an intrusion presentation system (IPS)(Jayesh et. al, 2017). It may also employ other techniques such as TLS/SSL

encrypted traffic inspection, website filtering, QoS/bandwidth management, antivirus inspections and third-party identity management integration such as LDAP, RADIUS, Active directory(Jayesh et. al, 2017). In this model NGFW were implanted to filter every service request coming from users to the DC's. In this model NGFW was not the only firewall implementing a personal firewall which is a software service running in an operating system . It gives a broad-based defense against hackers residing on other parts of the Internet.

- **Private cloud** (On-premises) were a local private cloud managed and controlled by Ethio telecom. Based on NIST cloud computing reference architecture the proposed private cloud consists of different layers which were used for different functions.

The first layer was an access layer contains interfaces used to interact with cloud user - like user portals provide an access path to specific web applications or services since everything is located on the web and can be accessed using a network connection, self-service API's, and customer UI's.

The second layer is service layer which contains different kinds of service provided and supported by the proposed cloud. These services are:-

- ✓ **Platform as a service (PaaS):** A category of cloud services where the capability provided to the cloud service user is to deploy onto the cloud infrastructure user-created or acquired applications developed using platform tools supported by the cloud service provider. Tools for application development, interface development, database development, storage and testing will be provided in this service.
- ✓ **Software as a service (SaaS):** A category of cloud service where the capability provided to the cloud service user is to use the cloud service provider's applications running on a cloud infrastructure like ERP,CRM,IPCC etc. applications.
- ✓ **Infrastructure as a service (IaaS):** A category of cloud services where the capability provided by the cloud service provider to the cloud service user is to provision processing, storage, network connectivity services (e.g. VLAN, firewall, load balancer, application acceleration), and other fundamental computing resources of the cloud infrastructure where the cloud service user is able to deploy and run arbitrary application.
- ✓ **Network as a service:-** category of cloud services where the capability provided to the cloud service user is to use transport connectivity services and/or inter-cloud network

connectivity services. This service includes include flexible and extended VPN, Bandwidth on demand etc.

- ✓ **Communication as a service:-** category of cloud services where the capability provided to the cloud service user is to use real time communication and collaboration services like Voice over IP, instant messaging, video conferencing for different user devices.

The physical layer in the stack is the infrastructure and virtualization layer, which includes all the physical computing resources. The layer includes hardware resources, such as computers (CPU and memory), networks (routers, firewalls, switches, network links and interfaces), storage components (hard disks) and other physical computing infrastructure elements. Resource abstraction components include software elements such as hypervisors, virtual machines, virtual data storage, and other computing resource abstractions is included in this layer. The resource abstraction needs to ensure efficient, secure, and reliable usage of the underlying physical resources. While virtual machine technology is commonly used at this layer, other means of providing the necessary software abstractions are also possible.

Cross layer functions include business continuity, security, and service management. Business continuity and security functions specify various activities, tasks, and processes that are required to offer reliable and secure cloud services to the consumers. Business continuity functions helps the user to specifies adoption of proactive and reactive measures to mitigate the impact of downtime, ensuring the availability of services in line with customer needs and supports all the layers to provide uninterrupted services. Security functions include and help to specifies the administrative mechanisms (security and personnel policies, standard procedures to direct safe execution of operations) and technical mechanisms (firewall, intrusion detection and prevention systems, antivirus),deploys security mechanisms to meet Ethio telecom requirements and supports all the layers to provide secure services. while service management function specifies various activities, tasks, and processes that enable the administrations of the cloud infrastructure and services to meet the provider's business requirements and consumer's expectations. Figure 4.3 shows components of proposed cloud deployment model.

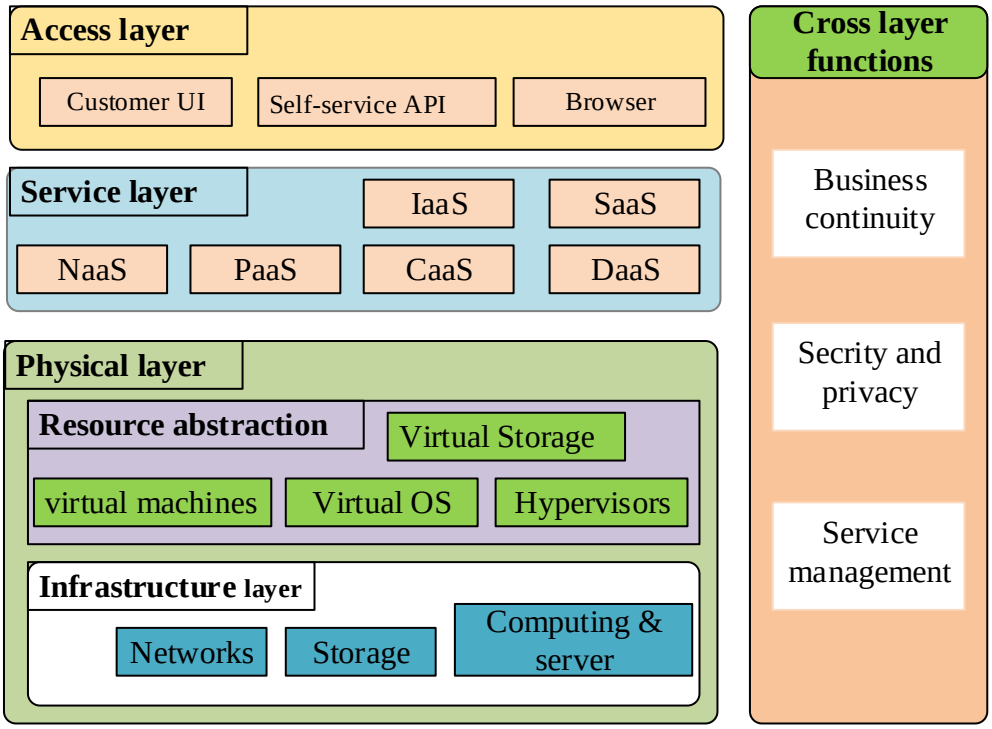


Figure 4. 3 Components of proposed cloud deployment model

Several techniques have been proposed by researchers for data protection and to attain highest level of data security in the cloud (Kannan,2019). Private cloud is the most secure cloud deployment model (Smoot & Tan, 2011). The data center built on premises with DMZ so that outside world cannot access internal resources from the internet, and it is a more secure cloud network. The proposed cloud model has to setup different security mechanism. From the user's access or employees' perspective, the cloud environment provides the multilayer security, Active Directory (AD), Federal Auth for authentication, identity, Identity and Access Management (AIM) and authorization for roles. From the data perspective, cloud offers security mechanisms including encryption, decryption, public key, private key, secret key, shared key, digital signature, etc. (Kannan,2019). From a network perspective, Cloud supports all version of Transport Layer Security (TLS) or Secure Socket Layer (SSL), Secure Shell (SSH) and Applicability Statement 2(AS2), and Network Access Control (NAC) (Smoot & Tan, 2011).

Private cloud (On-premises) was a local private cloud managed and controlled by Ethio telecom. The proposed private cloud consists of different layers which were used for different functions. The first layer is user layer contains interfaces used to interact with cloud users. The second layer

is service layer which contains different kinds of service provided and supported by the proposed cloud. The physical layer which include infrastructure and virtualization layer, which includes all the physical computing resources and cross layer functions include business continuity, security, and service management.

4.8 Discussion

The objective of this chapter was to propose a cloud computing deployment model that align with the specific needs of Ethio telecom. Document analysis and interviews were conducted to propose a cloud deployment model that aligns with specific needs of ethiotelecom.

The study found that a private cloud deployment model was best fit Ethio telecom business needs. A private cloud deployment model has a better performance in terms of both the ability of cloud model to fulfill a business needs and the level of cloud model to meet the factors to select a cloud deployment model. This shows that a private cloud deployment gives the case company ability to fully control over the data and process on-premises which allows the case company to manage the business-critical tasks, high quality of service ,excellent quality management, ensures higher security of sensitive data reliability for on-premises cloud environments. The negative side of this deployment model requires high IT infrastructure investment as well as high cost of managing and maintaining that infrastructure. The proposed model can also be used as a blueprint for implementing actual cloud-based services.

The findings of this research suggest that for organization adopting a cloud computing, organization first determine a business need, challenges of existing infrastructure or problem of how they can offer their customers a new service or capability before adopting a specific cloud deployment model that aligns with their needs.

In this research cost efficiency, security and privacy, data and application integration, scalability, performance, reliability, portability, ownership, user control and criticality of cloud service and types of workload were selected as parameters to select a best fit cloud deployment model. This parameter has indicated the best fit cloud computing model for the case company. But other criteria might lead to different cloud model, this can be identified by future study.

4.9 Chapter summary

This chapter provided a Cloud deployment model suitable for the case company. The chapter presented Ethio telecom infrastructure and service with description of basic service, critical systems, existing infrastructure, customer, and challenges. Based on the challenges and model selection criteria's different cloud computing deployment model alternatives were evaluated and a private cloud deployment model was proposed. Finally, the proposed cloud model components supported service and security mechanisms presented was evaluated.

CHAPTER FIVE
ETHIO TELECOM READINESS ASSESSMENT

5.1 Overview

In the previous chapter, a cloud deployment model suitable for the Ethio telecom were proposed. This chapter provides a readiness assessment for Ethio telecom to adopt the proposed cloud deployment model. This chapter starts by exploring overview of readiness assessment, then it discusses the method used in this paper to assess the readiness of Ethio telecom. It also presents the findings of the readiness assessment by different phases from identification, screening to categorizations. Based on the finding of the readiness assessment the proposed deployment model will be updated. Finally, a discussion of result will be presented .

5.2 Readiness Assessment

A cloud computing readiness assessment measure an organization how prepared for the change come with a cloud computing implementation (Loebbecke et al. 2011). It supports decision makers in understanding the organization's position regarding cloud computing, enables them to identify any gaps that may hinder cloud computing adoption and provides a tool to measure the progress of cloud computing over time in the organizations (Fawaz , 2017). The assessment will increase the awareness of cloud computing among the organization and increases the awareness of cloud computing among the organization (Oliveira,2014; Fawaz, 2017). It also saves time and increase the likelihood of successfully improving quality by identifying barriers the organization can address issues before they escalate to major problems(Oliveira, 2014).

5.3 Readiness Assessment Result

This section presents the readiness assessment result of each steps described in the previous sections by starting from identification to screening where evaluation was conducted then to categorization steps where application is categorized as ready to cloud or not ready to cloud.

5.3.1. Identification of IT Service and applications

The objective of this phase was to identify IT services and application to be further investigated regarding their cloud readiness and to identify the cloud-readiness criteria relevant to proposed

model. A total of 40 questionnaire was distributed to the targeted audiences and 29 response were received. The questionnaire response rate was 72.5 %. All the collected data was converted to excel sheet for conducting analysis.

- **Participants' Role in the Organization:** This item represents the role of the respondents inside the organisations. While more than half of the participants (55.0%) are staffs or IT specialists, 21.0% are working as expert and the remining 17% and 7% are working as managers and directors respectively in the organisations. This indicate that most of the respondents are IT specialists and experts who have some knowledge about the service or IT application used in ethiotelecom. This is similar with actual distribution of staff in IS division in Ethio telecom, where IT specialists and experts make up most of the staff. Figure 5.1 shows participants role in the organization.

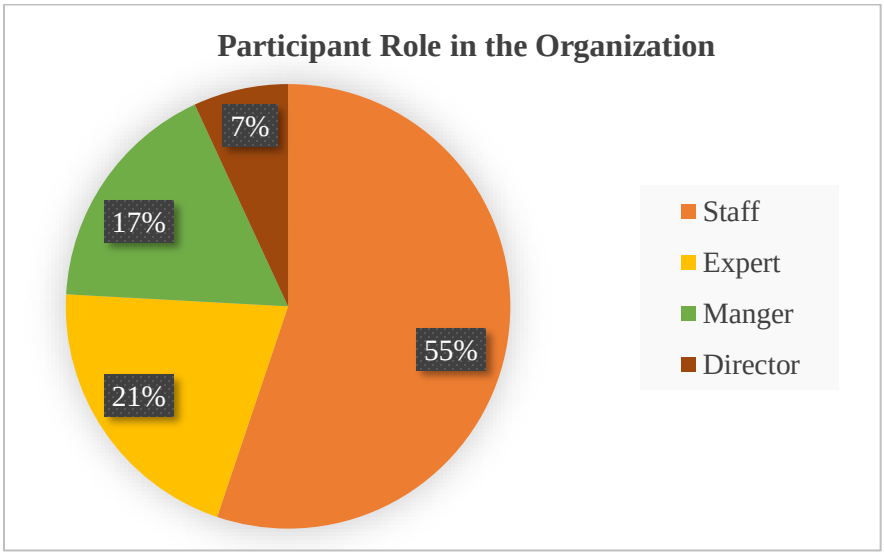


Figure 5.1 Participants' role in the organization

- **Participants' Experience:** This item represents the participants' years of relevant work experience: 48% have more than ten years' experience in the organization and 24% have between five to ten years' experience. This indicates that the study presents different views from participants with a range of work experience and opinions. Figure 5.2 Shows participants' experience profile.

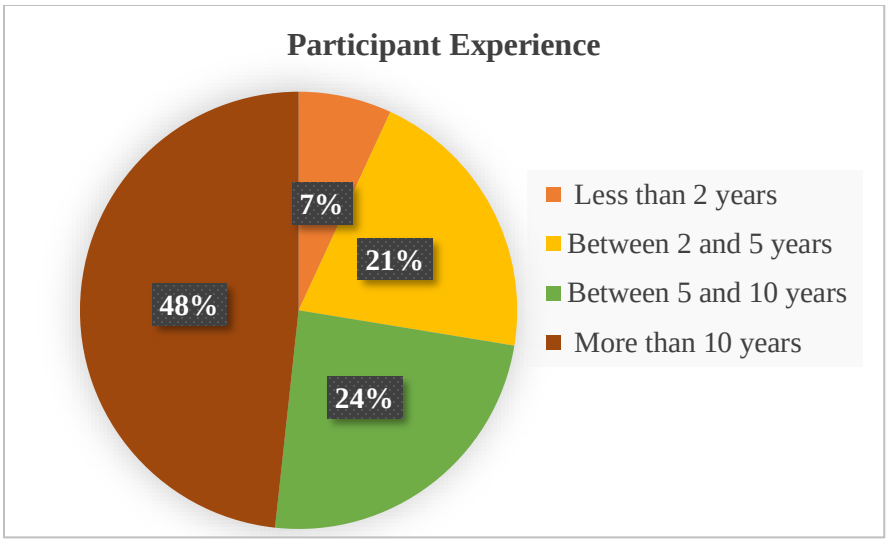


Figure 5.2 The participants' experience profile

- **Cloud Computing Awareness:** This item represents the participants' awareness for cloud computing. from the participants 79% of them have awareness of cloud computing while the rest do not have awareness. This indicates that most of the respondent have an awareness of cloud computing. Figure 5.3 shows participants' experience profile.

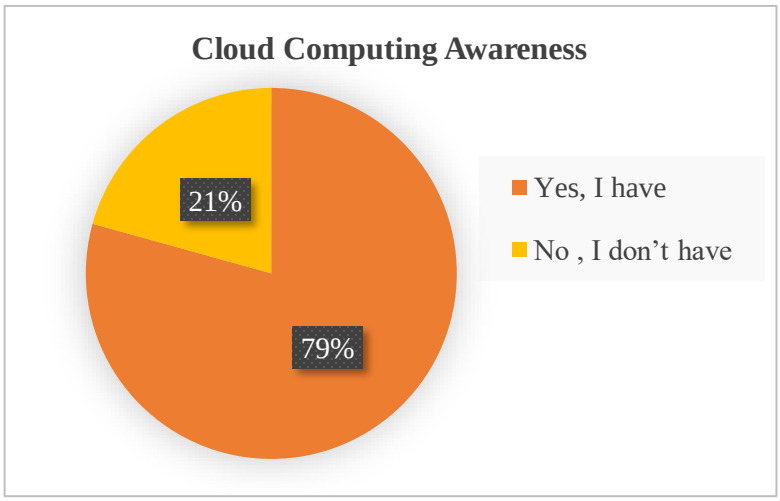


Figure 5.3 The participants' experience profile

5.3.2. IT services and applications

The respondent was asked to mention or list application or service they use, known or managed by their organizations. The objective of this item was to gather IT application and service that are to be investigated for cloud readiness from the respondent. Based on the questioner response, a

total of 26 IT service and application identified. The following bar chart show the frequency of each IT application and service mentioned with their respective name. Figure 5.4 shows the frequency IT application and service.

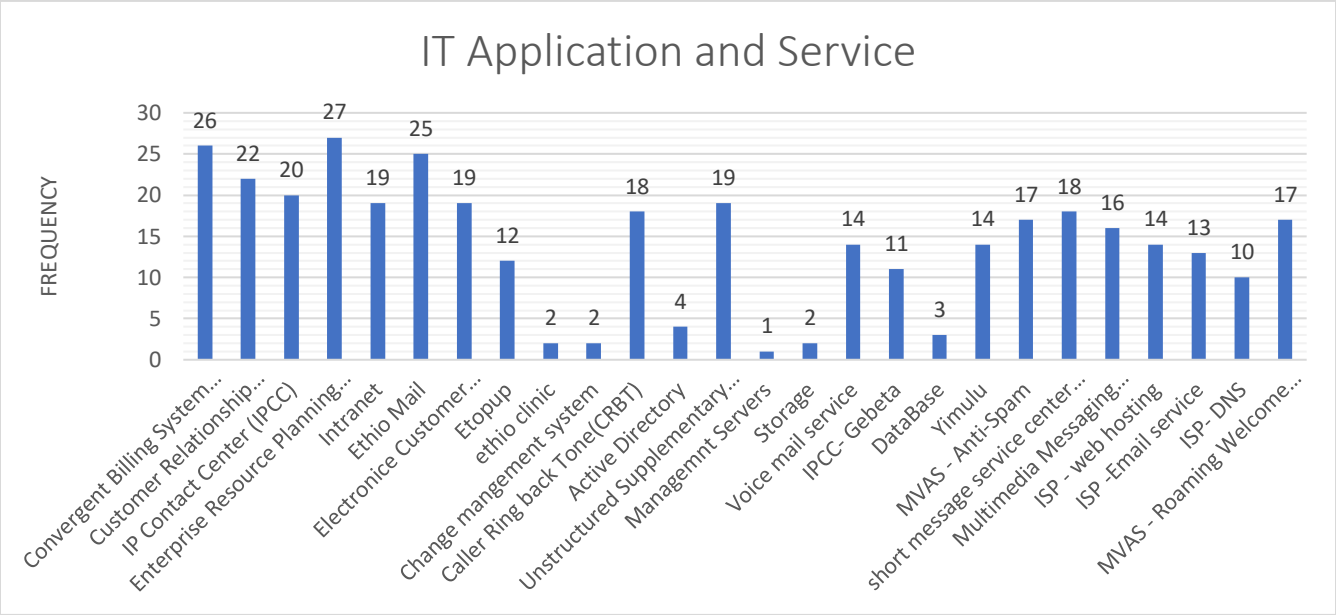


Figure 5.4 Frequency of IT application and service

Based on researcher document review and respondent from the questioners the following are list of IT service and application to be investigated for cloud readiness. IT service and application with frequency of below five were removed and the remaining 20 IT services and applications was investigated for cloud readiness. Table 5.1 shows IT service and application identified for Cloud readiness assessment.

IT Services and application Identified for Cloud Readiness Assessment		
Enterprise Resource Planning (ERP)	Convergent Billing System (CBS)	Ethio Mail**
Customer Relationship Management (CRM)	IP Contact Center (IPCC)	Electronic customer accusation form(Ecaf)
Intranet	Unstructured Supplementary Service Data (USSD)	Caller Ring back Tone (CRBT)
Short message service center (SMSC)	MVAS Anti-Spam	MVAS - Roaming Welcome Message
Voice mail service	Multimedia Messaging Service Center (MMSC)	ISP - Web hosting
Yimulu	ISP -Email service*	Etopup
IPCC- Gebeta	ISP- DNS	

*ISP -Email Service an email service for Ethio customers and **Ethio Mail for internal uses.

Table 5.1 IT Service and application identified for Cloud readiness assessment

5.3.3. Cloud readiness assessment criteria

Migrating application to the cloud is one of the biggest challenges that cloud paradigm has brought (Buyya et al., 2010). To migrate a service or application in a cloud environment, it is necessary to update the application to exploit these new capabilities and it is necessary to evaluate the application to migrate how and where the application is to be evolved (Corradini et al, 2015). Cloud readiness assessment of specific IT services need to be evaluated specifically in the context of the specific cloud deployment model (Loebbecke et al ,2012). In this section the research describes the criteria for assessing the cloud readiness of Ethio telecom IT services were identified in the previous sections. These criteria are adopted from Loebbecke et al ,2012 with a modification on general tendency for cloud readiness to fit the proposed cloud model which was a private deployment model. Each criterion has two parameters each with better and worst value to be assess the readiness of IT service to be cloud ready.

- **Core Business/Competitive Position :** Relevance for the core business and contribution to the competitive position are the two parameters in this criterion. Relevance for the core

business (high/low) high, if the service (significantly) contributes to turnover and profit (Loebbecke et.al ,2012). Contribution to the competitive position (differentiation / commodity) high, if an IT service or applications helps differentiation in terms of innovations, business process speed and agility (Loebbecke et al ,2012). A service with high relevance for the core business and high contribution to the competitive position (differentiation) is likely cloud ready.

- **Importance/ Availability:** The two parameters are importance and availability of the service. Importance (non-critical/critical): critical if core processes cannot run if the IT service is not available (Loebbecke et al ,2012). Availability (low/high): high if the IT service can be delivered without interruption (Loebbecke et al ,2012). The tendency for cloud reediness is an IT service or application that requires high availability and is critical important for core business processes is likely cloud ready.
- **Service standardization:** lifecycle and degree of standardization are the two parameters in service standardization criterion. Lifecycle (complex/simple): an IT service with strong integration into other systems and many dependencies to other processes is complex since its actualization requires intense planning and coordination (Loebbecke et al ,2012). Degree of standardization (high alignment/standard): standardized IT service are not adopted to company needs (Loebbecke et al ,2012). The tendency for cloud reediness is a standardize IT service or application with simple lifecycle is likely cloud ready.
- **Degree of Distribution:** Management (local/global): locally organized management task related to an IT service have no central administration structure (Loebbecke et al ,2012). Roles and rights differ among locations. Replication or technical administration (decentralized support service/ globally centralized). Hardware and software are centrally provided and configured. An IT service with global management and global technical administration is likely to be cloud ready.
- **Network Connectivity:** Bandwidth and latency/sensitivity are the two parameters in this criterion. The tendency for cloud readiness was an IT service or application with low bandwidth requirement and low latency/sensitivity is likely cloud ready (Loebbecke et al ,2012).
- **Identity Management**: Integration (strong/weak) and administrations (locally integrated /centralized) are two parameters. Integration (strong/weak): weak if an IT service has its

own identity management and is independent of the identity directory of the company /enterprise (Loebbecke et al ,2012). Administration is centralized if the provisioning and de-provisioning of users follows central guidelines, including conventions for naming and security (Loebbecke et al ,2012). The tendency for cloud readiness is an IT service or application with weakly integrated and centrally administrated identity management is likely cloud ready

- **Compliance:** Realization effort (high/low) and requirements (high/low) are the two parameters in service compliance criterion. Realization effort are high if extensive organizational and technical efforts are needed (Loebbecke et al ,2012). Requirements are high if the processed data need to match strict legal and regulatory standards, or company-specific compliance standards (Loebbecke et al ,2012). The tendency for cloud readiness is an IT service or application with low realization effort and high compliance requirement is likely cloud ready.
- **Service type**: Service architecture (client-server / Layered) and workload (Static/ Continuously grow) are the two parameters in this criterion. Continuously grow workload, If IT service utilizes IT resources with a utilization that grows or shrinks constantly overtime experience (Corradini et al, 2015). A layered service or application, If IT service that have a division between stateful and stateless components or layered as data layer, presentation layer and logic layer (Corradini et al, 2015). So, IT service or application with continuously grow workload and layered service or application is likely cloud ready.

5.3.4. Screening of IT Service and applications

The objective of this phase was to evaluate all identified service or application against all cloud readiness criteria for each IT service or applications and to determine which criteria are likely blocks for IT services to be ready for the proposed cloud model both individually and overall. A total of 70 questionnaire was distributed to the targeted audiences and 52 response were received. The questionnaire response rate was 74.25 %. All the collected data was converted to excel sheet for conducting analysis using Gartner Magic quadrant.

- **Participants' Role in the Organization :** This item represents the role of the respondents inside the organisations. 42% of the respondent are staff, 27% are working as expert , 19% of them are mangers and 8% of them are director. The remaining 4% are others. Most of

the respondents are staff and experts who are working in the service and application areas while the managers are decision makers. This is like the actual distribution of staff in IS division in Ethio telecom, where IT staff and experts make up most of the employee. Staff, experts, and managers are most of the respondents for evaluating cloud readiness of IT service and applications. Figure 5.5 shows the participants' experience profile.

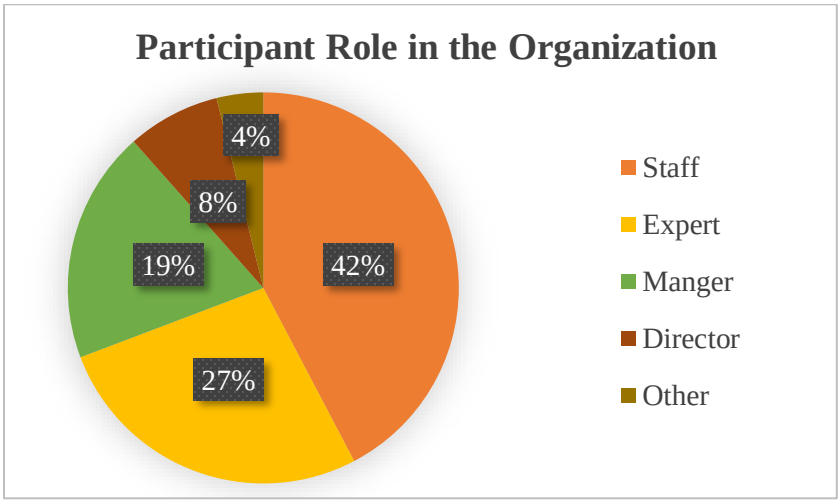


Figure 5.5 Participants role in the organization for screening

- **Participants' Experience:** This item represents the participants' years of relevant work experience: 38% of the respondents have a work experience of between two and five years, 25% of them have a work experience of between five and ten years, and 27% of them have more than ten years work experience. The remining 10% of respondent have less than two years' experience. Employee whose work experience above five years are most of the respondent for evaluating cloud readiness of IT service and applications. Figure 5.6 shows the participants' experience profile.

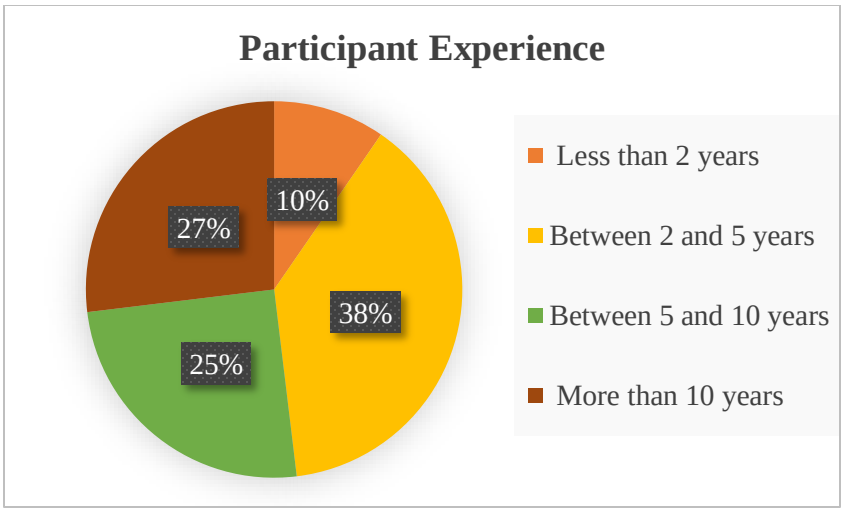


Figure 5.6 The participants experience profile for screening

5.4.2.1 Cloud readiness for IT service and application

The researcher identified and adopted a total of eight criteria to assess the cloud readiness of an IT service and application. Each criterion contains two parameters that are used in the evaluation process. The identified criterions are core business / competitive position, importance / availability, standardization, degree of distribution, network connectivity, identity management, compliance, and service type. The researcher develops eight magic matrices based on the identified criteria's and all IT services and application under consideration are placed in each of the Matrices to determine which criteria are likely blocks for IT services and application to be ready for the proposed cloud model both individually and overall. Appendix F shows the evaluation result of each criterion matric. In this section the assessment result of each criteria presented.

- **Core Business / Competitive Position**: The matrix for core business / competitive position criterion for cloud readiness was effectively meet for eleven IT service and applications that are clustered in the upper right of the matric: Yimulu, Etopup, IPCC- Gebeta ,VMS, ISP - Web hosting, ISP -Email service, CRM, SMSC, MVAS - Roaming Welcome Message, USSD and CBS. This IT service and applications are significantly contributes to turnover and profit and have a higher contribution to the competitive position. This suggests that the core business / competitive position criterion can be met for many IT services and applications. However, the lower left of the matric show that core business / competitive position criterion for cloud readiness does not met for six IT service and applications:

Intranet, MVAS Anti-Spam, ERP, ISP- DNS,IPCC and MMSC. This also indicate that the core business / competitive position criterion was the biggest barriers for the IT service and application cloud readiness for the proposed cloud model.

- **Importance / Availability:** The matrix for importance / availability criterion for cloud readiness was effectively met for 11 IT service and applications that are clustered in the upper right of the matric which are Intranet, IPCC- Gebeta, VMS, MVAS Anti-Spam, ERP, CBS,CRM, Ecaf ,SMSC, MVAS - Roaming Welcome Message and USSD. The number of applications met for importance / availability and for core business / competitive position criterion are the same. The lower left of the matric show that importance / availability criterion for cloud readiness does not met for three IT service and applications that are Yimulu, MMSC and CRBT. This suggested that the importance / availability position criterion can be met for many IT services and applications and it was also a barrier to three IT service and application cloud readiness for the proposed cloud model.
- **Standardization**: The matrix for service standardization criterion for cloud readiness was somehow meet for seven IT service and applications that are clustered in the upper right of the matric which are Intranet, Ethio Mail, ISP- DNS, ISP - Web hosting , ISP -Email service, MVAS Anti-Spam, Ecaf and MMSC. The lower left of the matric show that service standardization position criterion for cloud readiness does not met for four IT service and applications IPCC- Gebeta, VMS, Yimulu and CBS. This suggested that the standardization position criterion can be met for some IT services and applications and it also a barrier to four IT service and application cloud readiness for the proposed cloud model.
- **Degree of Distribution:** evaluation of degree of distribution of IT service and application with global management and global technical administration, the matrix for service degree of distribution position criterion for cloud readiness is effectively meet for 16 IT service and applications that are clustered in the upper right of the matric which are Intranet, Etopup, IPCC- Gebeta, ISP- DNS, Ethio Mail, IPCC,VMS, ISP-Web hosting, ERP, CBS, CRM, Ecaf, SMSC, MMSC, MVAS-Roaming Welcome Message and USSD. This suggests that the degree of distribution criterion can be met for almost all IT services and applications. But, the lower left of the matric show that degree of distribution position criterion for cloud readiness does not met for any IT service and applications which suggest that the degree of

distribution position criterion can enable Ethio telecom to adopt the proposed cloud deployment model.

- **Network Connectivity:** The matrix for network connectivity criterion for cloud readiness was effectively meet for 16 IT service and applications that are clustered in the upper right of the matric excluding Intranet, MVAS Anti-Spam, ISP-Web hosting and ISP-Email service. The lower left of the matric show that network connectivity position criterion for cloud readiness does not met for any IT service and applications. This two metrics suggests that network connectivity criterion can be meet for almost all IT services and applications and it can also one of the enablers for Ethio telecom to adopt the proposed cloud deployment model.
- **Identity Management:** The matrix for identity management criterion for cloud readiness was effectively met for 15 IT service and applications that are clustered in the upper right of the matric. Yimulu, Etopup, IPCC- Gebeta, ISP- DNS, IPCC, VMS,ISP - Web hosting, MVAS Anti-Spam, ERP, CBS, CRM, Ecaf, SMSC,MVAS-Roaming Welcome Message and USSD. This IT service and applications are weakly integrated and have a centrally administrated identity management. The lower left of the matric show that identity management criterion for cloud readiness does not met for any IT service and applications. This two metrics suggests that identity management criterion can be meet for many IT services and applications and it can also one of the enablers for Ethio telecom to adopt the proposed cloud deployment model.
- **Compliance:** The matrix for compliance criterion for cloud readiness is somehow meet for 11 IT service and applications that are clustered in the upper right of the matric which are IPCC- Gebeta, IPCC, VMS, ERP, CBS, CRM, Ecaf, SMSC, MMSC, MVAS - Roaming Welcome Message and USSD. The lower left of the matric show that compliance criterion for cloud readiness does not met for four IT service and applications are ISP- DNS, ISP - Web hosting, ISP -Email service and CRBT. This suggested that compliance criterion can be met for some IT services and applications and it also a barrier to four IT service and application cloud readiness for the proposed cloud model.
- **Service type :** The matrix for service type criterion for cloud readiness is somehow meet for 10 IT service and applications that are clustered in the upper right of the matric which are IPCC- Gebeta, IPCC, MVAS Anti-Spam, ERP, CBS, CRM, Ecaf, SMSC,MMSC and

CRBT. The lower left of the matric show that service type criterion for cloud readiness does not met for four IT service and applications Intranet, Yimulu, Etopup and ISP-DNS. This suggested that service type criterion can be meet for some IT services and applications and a barrier to four IT service and application cloud readiness for the proposed cloud model.

Overall assessment shows that the identified eight criterions are critical for different IT service and application. core business/competitive position are barrier to 6 IT service and application, standardization are barrier to 4 IT service and application ,compliance are barrier to 4 IT service and application, Service type are barrier to 4 IT service and application, and importance / availability are barrier to 3 IT service and application. On the other hand, degree of distribution, network connectivity, and identity management are enabler for Ethio telecom to adopt the proposed model since they are not barrier to any IT service and application during the screening phase.

5.3.5. Categorization of IT Service and applications

The objective of this phase was to categories the IT services and application as likely cloud ready or not cloud ready. Based on the magic matrix developed for each IT service and application in the previous phase, the researcher investigates all 20 identified IT services and application according to the eight criteria. The result of the investigation is attached on appendix F. The categorization of theses IT service and application are based on the following considerations:

- ✓ The position of soft threshold in the quadrant which is in dotted curve line. A service with all or most criteria above the threshold (upper right area) is likely cloud ready. This threshold is positioned by considering each matrix advantage and adopted from Loebbecke et al. (2011). It is consistent across all IT services and applications.
- ✓ A consideration for core business/competitive position criteria since it is emerged as the most critical one during the screening phase. If core business/competitive position criteria are above the threshold line with one most critical factor below the threshold, an IT service may be assessed as likely cloud ready. However, if core business/competitive position criteria are below the threshold line with one or more most critical factor below the threshold, an IT service may be assessed as likely cloud ready.

Based on the above consideration 20 IT service and application were investigated. Ethio mail, CRM, Ecaf, SMSC,USSD and MVAS-Roaming Welcome Message are service with all the criteria are above the threshold. While Etopup, CBS,VMS,IPCC Gebeta have one criterion below the threshold. However, for IT service and application like Intranet, ISP- DNS, IPCC, MVAS Anti-Spam, ERP and MMSC a core business/competitive position criterion was below the threshold which makes it not cloud ready. Other service like Yimulu, ISP - Web hosting, ISP -Email service and CRBT service have more than two critical criteria below the threshold. By considering the relative importance of the criteria as determined in the screening phase and categorizes the 20 IT services into likely cloud ready and not cloud ready, Ten of 20 IT services and applications resulted as 'likely cloud ready'. Table 5.2 shows IT service and application that resulted as likely cloud ready.

Likely Cloud Ready IT service and Applications	
Etopup	Customer Relationship Management (CRM)
IPCC- Gebeta	Electronic customer accusation form(Ecaf)
Ethio Mail	Short message service center (SMSC)
Voice mail service	MVAS - Roaming Welcome Message
Convergent Billing System (CBS)	Unstructured Supplementary Service Data (USSD)

Table 5.2 IT service and application categorized as likely cloud ready

5.4 Ethio telecom Cloud deployment model

In the previous sections, Ethio telecom cloud deployment model was proposed and Ethio telecom readiness assessment for adopting the proposed model was also conducted. Based on the result of readiness assessment Ethio telecom is currently in the early stage for implementing cloud computing and from identified 20 application and services, ten of them are likely cloud ready. A Cloud computing is not typically a total replacement for existing applications and services within the organization (CSCC, 2017a). As enterprises consider their cloud computing strategy, they will inevitably face the challenge of addressing how they will leverage their existing in-house IT investment with their newly adopted cloud services. Adoption of cloud services typically involves integration of the cloud services with the existing applications and systems (CSCC, 2017a ,2017b).

Integration involves several different components, both within the organization and within the cloud service provider(CSCC, 2017a). The components include data, where applications and services share common data or synchronization of some kind is required between data in-house and data in a cloud service, process integration between applications or services, where one application or service invokes operations provided by another as part of some workflow, management capabilities, which include the monitoring of cloud services and the control of cloud services which include security capabilities such as Identity and Access Management, and business capabilities including usage reporting, invoicing and payments (CSCC, 2017a ,2017b).

Ethio telecom can adopt the proposed cloud model by integrating on premises application and data with cloud service. This can help Ethio telecom to smoothly run their business without difficulties. Figure 5.7 shows the general architecture of proposed ethiotelecom cloud deployment model that includes on premises application and data.

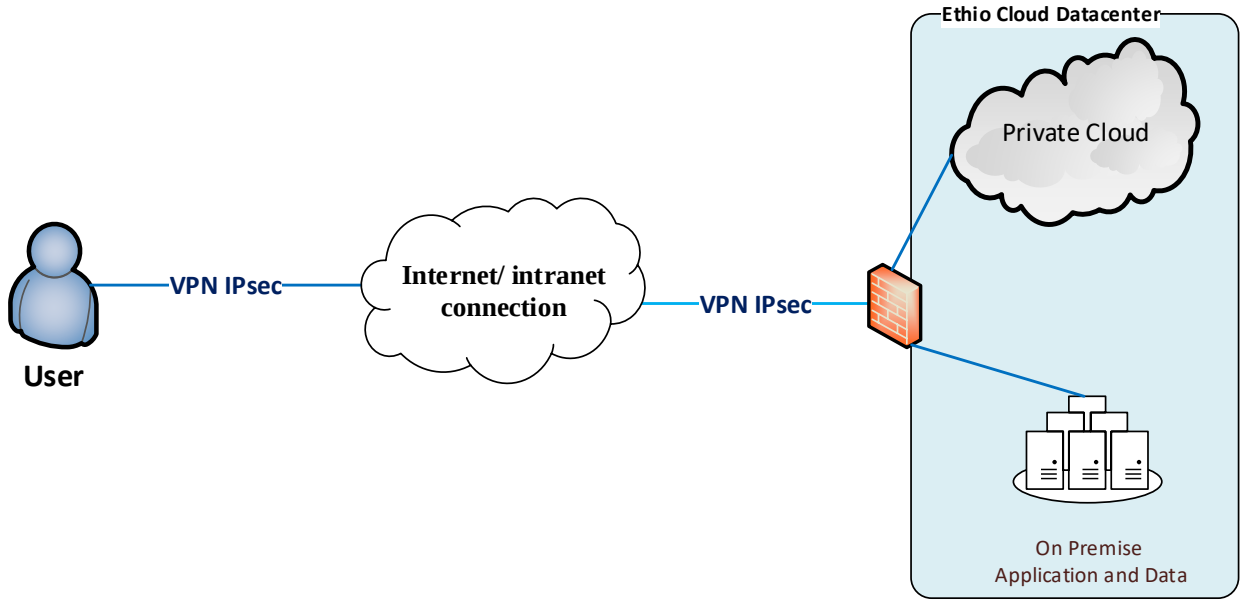


Figure 5.7 Updated proposed cloud deployment model

As shown from the figure this model includes different components to address business needs of the case company. Based on the finding of reediness assessment, Ethio telecom should integrate the existing on premises data and application with the proposed cloud service. This enable Ethio telecom to leverage advantage of both the cloud and on premises data and applications. Integrating cloud and on premises data and application reduced development costs and time required to integrate the use of the new cloud service, reduced maintenance costs to add new capabilities

,increased flexibility to integrate new services using the same legacy service, reduced costs and time to move a cloud service to a new cloud provider and lower costs to establish a disaster recovery plan (CSCC, 2017a ,2017b).

As new cloud services are deployed, the need to connect them or the applications running on them with various on-premises applications and systems becomes important(CSCC, 2016). This integration can be process (or control) integration, data integration or presentation integration. In the cross-layer function, integration management function as integrating both the cloud and on-premises application and data. This integration includes data integration where moving or federating data between prosed model and on-premises data source(Izza, 2009; Chen et al, 2008). Process integration between different applications/services on cloud and on pressies. Security integration where integration of the organization's Identity and Access Management (IdAM) system with the cloud service. Business logic integration to facilitate integration for the development of a middleware technology including usage reporting, invoicing, and payments. Presentation layer integration, the integration in this layer mainly focuses for effective user interface integration to take place on user interface (Daniel et al, 2007). Figure 5.8 shows updated components of proposed cloud deployment model.

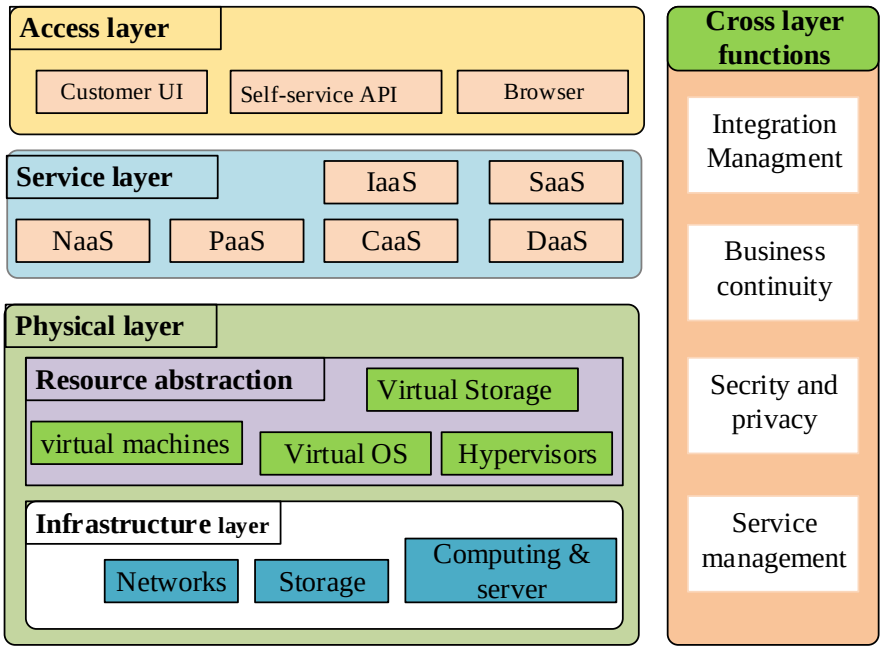


Figure 5.8 Updated components of proposed cloud deployment model

During cloud deployment ,the proposed cloud model includes application that are ready for the cloud like Etopup ,IPCC- Gebeta, Ethio Mail ,Voice mail service, CRM, CBS, Ecaf, SMSC, MVAS - Roaming Welcome Message and USSD with their data stored on cloud while application that are not ready for cloud with their data stored on premises application and data. There are several ways of establishing links between cloud services and existing applications and systems (CSCC, 2017a). Ethio telecom can use well-defined application program interfaces (APIs) for managing internal and external business services and delivering connectivity between on premises application and data, and the proposed cloud model. APIs make capabilities of an application or service available for use by other programs through a defined and controlled interface and protocol like SOAP,REST/JSON over HTTP which are commonly used for APIs (CSCC, 2014,2017a). The other mothed is implementing an Enterprise Service Bus (ESB) to perform interface, protocol, and data transformations to address differences between on-premises systems and cloud services (CSCC, 2016,2017a,2017b).

For a successful integration of on premises application and data with the proposed cloud, Ethio telecom should make a consideration Insisting the cloud service provider supports key open technologies (open standards API and/or open source, protocols, and data formats) for admin and business interfaces(CSCC, 2016,2017b). Ensure that on-premises applications are leveraging SOA design principles and can utilize and expose APIs to enable interoperability with proposed cloud service(CSCC, 2017b). Considering for implementing an Enterprise Service Bus (ESB) to perform interface, protocol, and data transformations to address differences between on-premises systems and proposed cloud services (CSCC,2017b,2016). Leveraging the support of third-party ID and Access Management functionality to authenticate and authorize access to cloud services. If cloud service(s) need access to on-premises APIs or data, address the security issues raised by enabling access to these capabilities from the cloud environment - for example, put in place suitable API Management capabilities to prevent unauthorized access (CSCC, 2016, 2017a,2017b).

Ethio telecom is benefited from the proposed model in terms of making their business agile. One of the main drivers of business agility is adoption of Technological innovations like cloud computing and information integration (infrastructure) is an important agility provider (Tseng & Lin,2011). Holbeche, (2015) also suggest that Technical integration of cloud with on premise service makes enterprise agile. Virtualization made organizations use their infrastructure in an

agile way (Pal & Pantaleo, 2005). Adoption this proposed model make Ethio telecom to more agile business environments.

5.5 Discussions

Different cloud deployment model satisfies different organizational needs and needs different readiness levels of the organizations to adopt specific cloud deployment model. The aim of this study to identify what kind of cloud computing deployment model best fit Ethio telecom and need to identify the readiness level of Ethio telecom to adopt the potential deployment model.

A private cloud deployment is proposed and assessment of ethiotelecom to adopt the proposed model were conducted using Gartner Magic Quadrant with methods adopted from Loebbecke et al (2012) and a modification made to the criteria to fit with proposed cloud deployment model. The finding of the study shows that core business/competitive, standardization, compliance, service type and importance/availability are barrier to different IT service and application. While degree of distribution, network connectivity, and identity management are enabler for Ethio telecom to adopt the proposed cloud deployment model.

Based on researcher observation and the result from data analysis, most of the respondent's employee and management team have a good awareness of cloud computing and some Ethio telecom current infrastructure is also changing to virtualized environment where physical resources are shared to do specific tasks. Virtualization is one of the key steps in the journey to private cloud. Ethio telecom have also the financial capacity to implement and manage cloud computing. Ethio telecom is currently in the early stage for implementing cloud computing since most of the IT application and service are not ready to move to clouds.

One of the Core business /competitive position of the organization was a barrier to IT Service and application to move to cloud. Adoption of cloud computing increases business agility where IT can be used as a competitive tools but moving core business functions onto cloud platforms is significantly more complex in terms of data management, system integration, greater costs and greater risk associated during migrations. Critical core processes should be delivered without interruption (Loebbecke et al ,2012). Interruption of this service led to serious risk to business. So Ethio telecom should start the adoption process stage by stage. Moving non-core application to the cloud and experiment with those before moving their core applications (Ruth, 2017).

A service standardization was also barrier for moving IT service to the proposed deployment model. A service with strong integration into other systems and many dependencies to other processes and service moving this service to cloud is complex since its actualization requires intense planning and coordination (Loebbecke et al ,2012). The same is true for IT service that are adopted to company needs.

In Ethio telecom, compliance issues regarding security, strict legal and regulatory standards, company-specific compliance standards and process control are the greatest obstacles to a more extensive move towards the proposed cloud model. Legal and compliance issues are very complicated when cloud is implemented because jurisdiction is not defined clearly (Rountree & Castrillo, 2013). Legal issues are the main discouraging factor for migrating to clouds (Rountree & Castrillo, 2013; Chandrasekaran, 2015).

Another barrier to migrate IT service and application into the proposed cloud model was a service type. Service or application with no subdivision between stateless and stateful components are related to each other and then it becomes difficult to carry out policies of scalability. In continuously grow workload, necessary resources are adapted to workload changes by provisioning and de-provisioning resources in an autonomic manner (Corradini et al, 2015). So, moving static workload application does not give any advantage (Corradini et al, 2015).

The findings of this study are promising in identifying factors that hindering cloud computing adoption in telecom industry. Ramzan et al. (2018) and Birhane (2018) conducted a study to identify determinants that influence the decision of organization to adopt a cloud computing from technological, organizational, and environmental perspective which is not include IT service and application of the organization. This addressed from IT service and applications perspective of the organization which is not included in pervious study. This study identifies factors hinder and allow for telecom application and service from moving to the cloud computing. The study is suggest that an organization should assesses the readiness level of an IT service and application before to adopt to cloud computing.

Ruth (2017) conducted study to assess the readiness level of Ethio Telecom to implement cloud computing services without identify whether Ethio telecom is eager to adopt cloud computing, what potential deployment model is best fit Ethio telecom needs. Lily (2017) conducted a study, but the finding did not show whether Ethio telecom has a willingness to adopt cloud computing and the level of readiness to adopt cloud computing is not clearly identify. In this study On

premises private cloud deployment model were proposed based on the ability of the cloud model to address or fulfill a business needs and the level of cloud model to meet the factors to select a cloud deployment model for Ethio telecom. The model shows that what a private cloud model look like on telecom sectors ,what service and application are used to implement cloud computing and the role of cloud computing in telecommunication sectors. The study also suggest that organization should first check their IT service need a cloud computing and based on the needs, a specific cloud deployment model can be selected to meet the busines needs. This is because each cloud deployment model satisfies different organizational needs and needs different readiness levels of the organizations (Rountree & Castrillo, 2013).

This study also strength the finding of Satheesh & Rao (2016) and Zhou et. al, (2010). Cloud computing in telecom sector can improve the performance of IT service and application provided. The telecommunication operator and business partner can win more profit and significantly enhance the diversity of value-added services with lower cost and shorter time to market using cloud computing (Zhou et. al, 2010).

The findings in different phases of this study suggest that Ethio telecom should give emphasis to use the proposed model. Before moving to cloud, Ethio telecom should assess the level of integration and dependence between the service, a service with dependencies to other processes is complex since its actualization requires intense planning and coordination (Loebbecke et al. 2011). Ethio telecom should receive their IT policy's and strategy before moving to cloud since compliance one of the barriers to move to cloud. Migrations of core business service to cloud have serious risk and this risk should be carefully mitigated for successful adoption of cloud computing.

The finding of this research in identifying factors hindering adoption proposed cloud model but, the assessment method was more focused on technological side of cloud adoption. A future study can address this limitation by assessing readiness from human, environmental, strategical and financial perspective. Some of the assessment criteria was overlap, they should be weighted for an effective readiness assessment and selecting cloud ready IT service.

5.6 Chapter Summary

In this chapter, a readiness assessment for Ethio telecom to adopt the proposed cloud deployment model were conducted. A Gartner magic quadrant were used for conducting analysis. Core

business/competitive position, standardization, compliance, service type and importance / availability are barrier for Ethio telecom from adopting the proposed cloud model while degree of distribution, network connectivity, and identity management are enabler for Ethio telecom to adopt the proposed model. The findings of the readiness assessment result by different phases from identification, screening to categorizations were presented. Based on the finding of the readiness assessment the proposed model were updated. Finally, a discussion was presented. Conclusion and recommendation will be presented in the next chapter.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

The final chapter presents the conclusion of the study and the recommendation based on the findings of the research. Furthermore, the chapter proposes possible ideas for future research and limitation of the study.

6.1 Conclusion

The main objective of this research was to propose a cloud computing deployment model that aligns with the specific need of Ethio telecom and to assess the readiness level of Ethio telecom to adopt the potential deployment model.

A customized cloud computing deployment model can proposed from different models for deployment. The selection process should include the business needs and corporate cloud strategy, determines which cloud deployment technologies are relevant and addresses specific application/service needs. There are many factors pushing organizations toward the cloud, as well as many factors that are keeping organizations away. Organization must periodically re-assess the respective value and fit of various cloud deployment technologies to their business needs. since each cloud deployment model satisfies different organizational needs. advantage of selecting specific cloud model based on the organization needs enables organization to successfully utilize the merit of the model and helps to minimize the risk associated with specific cloud deployment model. The study identifies the business need and proposed on premises private cloud deployment model based on the identified business needs. Easily manageable datacenter, flexible storage, updated technology, effective resource utilization and improved business agility are Ethio telecom's cloud computing deployment model needs. The proposed model enables the organization to identify the right cloud deployment model for their business needs and the status of the organization to adopt cloud computing.

Organization should also measure their readiness level to understand how they prepared for the change come along with a cloud compute implementation. It also helps to identify organization strengths that can be used to support cloud computing initiative and to understand current infrastructure issues need solution before migrating to cloud computing. This study confirms that

core business /competitive position, standardization, compliance, service type and importance/availability are barrier to different IT service and application from migrating to proposed cloud model. While degree of distribution, network connectivity, and identity management are enablers for adopting the proposed cloud deployment model. The reediness assessment in this study focus more on IT service and application readiness towards the proposed cloud model, which is not includes other perspective like Organization ,environmental factors.

6.2 Recommendation

Telecom operators align themselves in cloud value chain as cloud service providers, cloud service users and both as users and providers. In this study we are limited only to Ethio telecom as a cloud user. A future study can propose a model for Ethio telecom both a user and cloud service provider. Based on the above findings of the research, the following suggestions are put forward for Ethio telecom.

- In this paper the readiness for cloud computing is based on application service but Ethio telecom should assess other areas like human, environmental, strategical ,financial factors before adopting a cloud model to improve their chances of success in adopting cloud computing.
- The proposed cloud deployment model was based on the combination of the ability of the cloud model to address or fulfill a business needs and the level of cloud model to meet the factors to select a cloud deployment model. This the impacts of the factors and business need may change through time. Ethio telecom should take this study as a benchmark and propose a cloud model from different perspective like as a cloud provider for further evaluation for deployment model.
- It is also advice for Ethio Telecom and for other organization to begin their cloud computing adoption in stages. They should start by moving their non-core service to the cloud and experiment with those before moving their core service.
- There is a wide range of research area on Cloud Computing because it is still in its early stages. This research focused in Ethio Telecom specifically, future research could focus on another industry or organization as the result of this research cannot be generalized. The results from different research across several industries could be combined in future to come up with solution that could be applied across several industries.

6.3 Research contribution and implications

The thesis contributes to the body of knowledge on the adoption of cloud computing in many aspects, as follows:

- The thesis contributes to the body of knowledge by providing a comprehensive literature review about various aspects of cloud computing. The thesis critically reviewed several cloud computing deployment models, service model, the benefits of cloud computing and the issues of cloud implementation. It also includes literature about the use of cloud computing in telecom operators and the role of cloud computing in telecommunication sectors.
- The research community will benefit from this research because it will contribute to the existing body of knowledge, especially in cloud computing deployment models. Additionally, the study could be used as a baseline for further studies to be considered in different governmental and nongovernmental organizations of Ethiopia. Furthermore, it helps cloud vendors by providing them country and sector-specific factors that they need to consider adjusting their services and rethink their marketing strategies.
- For the organization, the proposed model will enable an organization to identify the right cloud deployment model for their business needs, the current status of the organization to adopt cloud computing and helps to understand the barriers and enablers of cloud computing readiness.

6.4 Limitation of the study

The research work has got some limitations in its nature. One of the limitations is that the study was conducted using samples from only one division of Ethio telecom. This would limit information about the awareness of other employees on cloud computing and application that are used in other division. Being a single case study would also limit the amount information on the research interest. This is because Ethio telecom is sole services provider and the study did not get the chance to make a comparative between the telecom companies. Telecom operators align themselves in cloud value chain as cloud service providers, cloud service users and both as users and providers. This study takes Ethio telecom as a cloud user, the finding of this result cannot be generalized to other telecom service provider who use and provide a cloud service.

The readiness assessment method focuses on the operational level of the organisations by investigating selected IT services and applications. Although this method provides an in-depth understanding of the technological side of Cloud Computing adoption, it focuses more on the operational level and ignores the strategic level of decision-making, human, organizational, and environmental.

6.5 Future work

The overview of the research, the discussions, the findings, and the limitations of the thesis suggest some aspects are beyond the scope of this research and recommended for future work, as follows:

- Telecom operators align themselves in cloud value chain as cloud service providers, cloud service users and both as users and providers. In this study we are limited only to Ethio telecom as a cloud user. A future study can propose a model for Ethio telecom both a user and cloud service provider.
- A private cloud deployment model was proposed in this paper based on nine criteria to compare the different cloud models. But other criteria cloud lead to different cloud model so a future study can use other criteria to enhance or improve this model.
- A cloud implementation architecture is not studied in this paper a future study can develop an implementation architecture for the proposed cloud deployment model.
- A cloud deployment model uses different cloud computing service, in this paper the types of cloud computing service is not studied a future study can look in deep what kind of cloud computing service should be used by this proposed cloud model.

REFERENCE

Ahmed, Y. (2012). Exploring Cloud Computing Services and Applications. *Journal of Emerging Trends in Computing and Information Sciences,* 3(60),838-847.

Aladwani, A.M. (2001). Change management strategies for successful ERP implementation. *Business Process Management Journal,* 7(3), 266-275.

Alemayehu, A. (2014). A Cloud Computing Framework for Ethiopian Banking Industry (Unpublished Master's Thesis). Addis Ababa University, Addis Ababa.

Alemayehu, A. (2015). Cloud Computing Readiness of Some Selected Organizations in Ethiopia: Towards A Strategic Guideline (Unpublished Master's Thesis). Addis Ababa University, Addis Ababa.

Ali Babar, M., & Chauhan, M. A. (2011). A Tale of Migration to Cloud Computing for Sharing Experiences and Observations. *In SECLOUD 11. Proceedings of the 2nd International Workshop on Software Engineering for Cloud Computing* (pp. 50-56). ACM Conference on Computer-Human Interaction.

Alkhater, N., Wills, G. and Walters, R. (2014) Factors Influencing an Organization's Intention to Adopt Cloud Computing in Saudi Arabia. *Proceedings of the IEEE 6th International Conference on Cloud Computing Technology and Science* (pp. 1040-1044), Singapore.

Alonso, J., Orue-Echevarria, L., Escalante, M., Gorronogoitia, J. & Presenza, D. (2013). Cloud modernization assessment framework: Analyzing the impact of a potential migration to Cloud. In*: 7th IEEE International Symposium on the Maintenance and Evolution of Service-Oriented and Cloud-Based Systems (MESOCA).* pp. 64–73.

Alvarez,C. A. M. (2011), "Cloud computing: Concerns and challenges for its adoption in SME's and large companies in japan, (Unpublished Master's Thesis). Asia-Pacific University, Kuala Lumpur.

Andrikopoulos, V., Darrow, A., Karastoyanova, D., & Leymann, F. (2014) CloudDSF-The cloud Decision Support Framework for Application Migration. Service-Oriented and Cloud Computing: *Third European Conferenc*e (pp.1-16), Manchester, United Kingdom, ESOCC.

Anstett, T., Leymann, F., Retter, R., & Strauch, S. (2009). Towards BPEL in the Cloud: Exploiting Different Delivery Models for the Execution of Business Processes. Congress on Services. (pp.670-677), Los Angeles, CA

Armbrust, M., Fox, A., Griffith, R., Joseph, A.D., Katz, R.H., Konwinski, A., Lee, G., Patterson, D.A., Rabkin, A., Stoica, I., & Zaharia, M. (2009). Above the Clouds: A Berkeley View of Cloud Computing. Retrieved from University of California Database, https://www2.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf.

Arutyunov, V. (2012). Cloud computing: Its history of development, modern state, and future considerations. Scientific and Technical Information Processing, 39(3), 173-178.

Asatiani, A., Apte, U., Penttinen, E., Rönkkö, M., & Saarinen, T. (2014). Outsourcing of Disaggregated Services in Cloud-Based Enterprise Information Systems. *47th Hawaii International Conference on System Sciences* (pp. 1268-1277), Waikoloa, Hawaii, HICSS.

Aschalew G. (2018), Context Based Cloud Service Architecture: From Carrier Perspective (Unpublished Master's Thesis). Addis Ababa University, Addis Ababa.

Bell, E., & Bryman, A. (2007). The ethics of management research: an exploratory content analysis. British Journal of Management,18(1),63-77.

Benslimane, Y., Plaisent, M., Bernard, P., Bahli, B. & Rennes, E.S.C. (2014). Key Challenges and Opportunities in Cloud Computing and Implications on Service Requirements: Evidence from a Systematic Literature Review. *In: IEEE 6th International Conference on Cloud Computing Technology and Science* (pp.114-121). Singapore. Retrieved from http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=7037656.

Benbasat, I., Goldstein, D.K., Mead, M., 1987. The case research strategy in studies of information systems. MIS Quarterly11, 369–386.

Birhane W. (2018), Cloud Adoption Framework for Small and Medium-Size Enterprises (SMEs) in Ethiopia (Unpublished Master's Thesis). Addis Ababa University, Addis Ababa.

Bider, I., & Perjons, E. (2012.). Preparing for the era of cloud computing: Towards a framework for selecting business process support services. *In Enterprise, Business-Process and Information Systems Modeling. Springer Berlin Heidelberg*, pp (16–30).

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology. 3 (2), 77–101.

Bryman, A. (2004). Research methods and Organization studies. London, Routledge.

Buyyaa R., Yeoa, C. S., Venugopala, S., Broberg, J., & Brandic, I. (2009) 'Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility, Future Generation Computer Systems, 25(6) pp.599–616.

Buyya, R., Broberg, J. & Goscinski, A.M. (2010). Cloud Computing: Principles and Paradigms. Hoboken, New Jersey, Wiley. John Wiley & Sons, Inc.

Caifeng, Z., Huifang, D., & Qunye, Q. (2013). Designing and Implementation of Hybrid cloud computing architecture based on Cloud Bus. In IEEE 9th International Conference on Mobile Ad-hoc and Sensor Networks, 290-293.

Calabrese, B. & Cannataro, M. (2015). Cloud Computing in Healthcare and Biomedicine. Scalable Computing: Practice and Experience.16 (1),1–18.

Carroll, M., Kotzé, P., & Merwe, A.V. (2011). Secure cloud computing: Benefits, risks and controls. 2011 Information Security for South Africa, 1-9.

Chandrasekaran,K.(2015), Essentials of Cloud Computing, Newyork, USA, CRC Press Taylor & Francis Group.

Chandrashekhar, M., & Shashikumar, M.(2017). Cloud Computing Service and Deployment Models. International Journal for Research in Applied Science & Engineering Technology (IJRASET), 5(6),1083-1088

Chang, V., Walters, R.J. & Wills, G. (2014). Review of Cloud Computing and existing frameworks for Cloud adoption. In: M. Ramachandran (ed.). Advances in Cloud Computing Research. Nova Science Publishers.

Chen, I.J., & Popovich, K. (2003). Understanding customer relationship management (CRM): People, process, and technology. Journal of business Process Management, 9(5), 672-688.

Chen, D., Doumeingtsb, G., & Vernadatc, F.(2008). Architectures for Enterprise Integration and Interoperability: Past, present, and future. *In: Computers in industry*,59(7), pp.647 -659.

Chuang, T.-T., Nakatani, K. & Chen, T.T. (2015). An exploratory study of expected business value of cloud computing. Issues in Information Systems.16 (4).37–47. Retrieved from http://www.iacis.org/iis/2015/4_iis_2015_37-47.pdf

Cloud Standards Customer Council(CSCC) (2017a). Practical Guide to Cloud Deployment Technologies Version 3.0, Retrieved from https://www.omg.org/cloud/deliverables/CSCC-Practical-Guide-to-Cloud-Computing.pdf

Cloud Standards Customer Council(CSCC) (2017b). Interoperability and Portability for Cloud Computing: A Guide Version 3.0, Retrieved from http://www.cloud-council.org/resource-hub.htm#interoperability-and-portability-for-cloud-computing-a-guide

Cloud Standards Customer Council(2014). Practical Guide to Cloud Deployment Technologies

Version 2.0., Retrieved from http://www.thesupplychaincloud.com/wp-content/uploads/2016/07/Practical-Guide-To-Cloud-Computing.pdf

Cloud Standards Customer Council (CSCC)(2016) Practical Guide to Hybrid Cloud Computing. http://www.cloud-council.org/deliverables/practical-guide-to-hybrid-cloud-computing.htm

Corradini, F., Angelis, F.D., Polini, A., & Sabbatini, S. (2015). Cloud Readiness Assessment of Legacy Application. *In Proceedings of the 5th International Conference on Cloud Computing and Services Science (CLOSER-2015), 119-126,* DOI: 10.5220/0005443301190126.

Creswell, J.W. (2013). Research design: Qualitative, quantitative, and mixed methods approaches. Sage.

Dai, L., Gao, X., Guo, Y., Xiao, J. & Zhang, Z. (2012). Bioinformatics clouds for big data manipulation. Biology direct.7 (43).2–7. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3533974&tool=pmcentrez&rendertype=abstract

Daniel, F., Yu, J., Benatallah, B., Casati, F., Matera, M., & Saint-Paul, R.(2007). Understanding UI integration: A survey of Problems, Technologies, and Opportunities. In: IEEE Internet Computing., 11(3), pp.59 -66, doi:10.1109/MIC.2007.74

Dawson. D. C.,(2009), Introduction to Research Methods A practical guide, 4th ed., Beg broke, Oxford.

Dillon, T., Wu, C. & Chang, E. (2010). Cloud computing: issues and challenges. In: 24th IEEE International Conference on Advanced Information Networking and Applications (AINA)(pp. 27-33). Perth, IEEE.

Doherty. E, Carcary,M. & Conway. G. , (2015) "Migrating to the cloud: Examining the drivers and barriers to adoption of cloud computing by SMEs in Ireland: an exploratory study", Journal of Small Business and Enterprise Development, 22(3),512 – 527.

Dubey A.(2016),Cloud computing and its security issues, International Journal of Advance Research in Computer Science and Management Studies,4(7).

Ethio telecom. (n.d. -a). Brief historical review of telecom sector in Ethiopia. Retrieved from https://www.ethiotelecom.et/our-history/

Ethio telecom.(2020 - b). Ethio telecom 2012 EFY (2019/20) Quarter I Business Performance.

Retrieved from https://www.ethiotelecom.et/የ2012-በጀት-ዓመት-የመጀመሪያ-ሩብ-ዓመት-የሥራ/

Ethio telecom. (n.d.-c). Brief historical review. Retrieved from https://www.ethiotelecom.et/about-us/

Ethio telecom. (n.d.-d). Ethio telecom service. Retrieved from https://www.ethiotelecom.et/services/

Ericsson.(2012). The telecom cloud opportunity[discussion paper] Australia. Retrieved from https://cloud.report/Resources/Whitepapers/e954adbf-f6ad-4567-8bea-1a11bab4aa07_The%20Telecom%20Cloud%20Opportunity.pdf"

Erl, T., Puttini, R. & Mahmood, Z. (2013). Cloud Computing: Concepts, Technology & Architecture. The Prentice Hall.

Fawaz .A. (2017).Holistic Approach Framework for Cloud Computing Strategic Decision-Making in the Healthcare Sector (HAF-CCS). (Unpublished Desertion). Staffordshire University, Stoke-on-Trent.

Ferguson-Boucher, K. & Convery, N. (2011). Storing information in the cloud - a research project"", Journal of the Society of Archivists, 32(2), 221-239.

Gale, N.K., Heath, G., Cameron, E., Rashid, S. & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. BMC medical research methodology,13 (1),117.

Garg, S.K. & Buyya, R. (2012). Green Cloud computing and Environmental Sustainability. In: M. San & G. R. Gangadharan (eds.). Harnessing Green IT: Principles and Practices. (pp. 315–340). John Wiley & Son.

Garg, S. K., Versteeg, S., & Buyya, R. (2013). A framework for ranking of cloud computing services. Future Generations Computer Systems Journal, 29(4), 1012–1023. doi:10.1016/j.future.2012.06.006

Gartner. (n.d.). Gartner Magic Quadrant. Retrieved from https://www.gartner.com/en/research/methodologies/magic-quadrants-research

Given, L. M. (2008). The Sage encyclopedia of qualitative research methods. Los Angeles, Calif: Sage Publications.

Güner, E.O. and Sneiders,E.(2014). Cloud Computing Adoption Factors in Turkish Large Scale Enterprises. in *Pacific Asia Conference on Information Systems*(p.353). Chengdu. PACIS

Gupta, P., Seetharaman, a. & Raj, J.R. (2013). The usage and adoption of cloud computing by small and medium businesses. International Journal of Information Management.33(5), 861–874.

Guruh, A., Daniel, K., & Mufadhol (2018), Hybrid cloud: bridging of private and public cloud computing , IOP Conf. Series: Journal of Physics: Conference. Series 1025 doi :10.1088/1742-6596/1025/1/01209

Hauck, M., Huber, M., Klems, M., Kounev, S., Müller-Quade, J., Pretschner, A., & Tai, S. (2010). Challenges and opportunities of cloud computing. Karlsruhe Reports in Informatics, 19. Retrieved from http://digbib.ubka.unikarlsruhe.de/volltexte/documents/1978786.

Hibatullah A. (2016), A Brief Survey of Cloud Computing, Global Journal of Computer Science and Technology, 16(3).

Hill, J. B., Cantara, M., Kerremans, M., & Plummer, D. C. (2009). *Magic quadrant for business process management suites*. Gartner Research, 164485.

Holbeche, L. (2015). The Agile Organization: How to build an innovative, sustainable, and resilient business. Kogan Page Publishers.

Hsu, P.-F., Ray, S. & Li-Hsieh, Y.-Y. (2014). Examining cloud computing adoption intention, pricing mechanism, and deployment model. International Journal of Information Management.34 (4), 474–488.

Hudaib, A., Alnabhan, M., Harfoushi, O., Obiedat, R., Adwan, O. & Adham, W. (2014). Emerging Trends of Outsourcing Business to Cloud Computing Services : A Perspective Study. Journal of Communications and Network. 6 (1),1–8.

Izza, S.(2009). Integration of industrial information systems: From syntactic to semantic integration approaches. *In: Enterprise Information system*, 3(1), pp.1 -57.

James, N., &Tridip, K.(2015). Selecting Cloud Deployment Model Using a Delphi Analytic Hierarchy Process (DAHP). *Industrial and Systems Engineering Review*, 3(1)

Jan G., Ola H., Ig nacio M., & Robert S. (2010) "Cloud Computing in Telecommunications, Ericsson Review

Jan j. & Bartjan P.(2010), The Essence of Research Methodology, 1st ed., Heidelberg: Springer.

Jayesh, S., Kriti S., Neha, B., & Nivedita M., & Nupur J. (2017), International Journal of Engineering Development and Research,5(2),984-988.

Judith, B., (2015).Cloud Computing Security with VPN. International Journal of Advanced Research in Computer and Communication Engineering, 4(8),100-103.

Karandeep, K.(2016). A Review of Cloud Computing Service Models. *International Journal of Computer Applications.* 10(7) 15-18.

Katica, N., & Tahirovic, A. (2012). Opportunities for telecom operators in cloud computing business. *In Proceedings of the 35th International Convention* MIPRO, 495-500.

Khanagha, S., Volberda, H., Sidhu, J. & Oshri, I. (2013). Management Innovation and Adoption of Emerging Technologies: The Case of Cloud Computing. European Management Review. 10 (1),51–67.

Khurana,S. & Verma, A. (2013), *Comparison of Cloud Computing Service Models: SaaS, PaaS, IaaS*", International Journal of Electronics & Communication Technology, 4(3),29-32.

Klems, M., Nimis, J., & Tai, S. (2009), "Do Clouds Compute? A framework for Estimating the value of Cloud Computing. *In: Weinhardt C.,Luckner S.,Stober J.(eds) Designing E-business systems. Markets, services, and network. Web 2008. Lecturer notes in business information processing vol 22.* Springer-Verlag Berlin Heidelberg. Retrieved from https://doi.org/10.1007/978-3-642-01256-3_10

Kliazovich, D., Bouvry, P., & Khan, S.U. (2010). Green Cloud: a packet-level simulator of energy-aware cloud computing data centers. The Journal of Super computing, 62, 1263-1275

Kothari, C. (2004). Research Methodology: methods and techniques (2nded). New Delhi: New Age International Publication.

Kotrlik, J. W. K. J. W., & Higgins, C. (2001). Organizational research: Determining appropriate sample size in survey research appropriate sample size in survey research. Information Technology, Learning, and Performance Journal, 19(1), 43.

Laili, Y. ,Tao, F., Zhang, L., Y. Cheng, Luo, Y. & Sarker,B. (2013),A Ranking Chaos Algorithm for dual scheduling of cloud service and computing resource in private cloud. Journal of Computers in Industry, 64(4),448-463.

Leedy, P.D. & Ormrod, J.E. (2005). Practical Research: Planning and Design. 8th Ed. Prentice Hall.

Lensa B. (2017). Cloud Computing Readiness Assessment for banking sector in Ethiopia (Unpublished Master's Thesis). Addis Ababa University, Addis Ababa.

Lin G., Fu D., Zhu J., & Dasmalchi G.,(2009).Cloud computing: IT as service, *IT Professional, 11(2),*10-13.

Lily K. (2017). Impact Analysis of Desktop Cloud Computing in the Case of Ethio Telecom (Unpublished Master's Thesis). Addis Ababa University, Addis Ababa.

Loebbecke, C., Thomas, B. and Ullrich, T. 2011. Assessing Cloud Readiness: Introducing the Magic Matrices Method Used by Continental AG. *IFIP International Working Conference on Governance and Sustainability in Information Systems-Managing the Transfer and Diffusion of IT* , 270–281.

Lupse, O.S., Vida, M.M., & Stoicu-Tivadar, L. (2012).Cloud Computing and Interoperability in Healthcare Information Systems. *In: The First International Conference on Intelligent Systems and Applications* (pp.81-85) INTELLI ,Mont Blanc, France.

Mahesh S. Kavre, Vaibhav S. Narwane & Rakesh D. Raut,(2017),Cloud Adoption in Various Domains and Factors Influencing Its Adoption, *International Conference on Emanations in Modern Technology and Engineering* (ICEMTE), 5(3),335 - 338.

Mahyar, A., Nazli , S., Seyyed, M., & Azam, A.(2013). Type of Cloud Computing (Public and Private) That Transform the Organization More Effectively. *International Journal of Engineering Research & Technology (IJERT),*2(5).

Marinescu, D. C. (2013). Cloud Computing: Theory and Practice. Boston: Morgan Kaufmann.

Maqueira-Marín, J., Bruque-Cámara, S. and Minguela-Rata, B. (2017), "Environment determinants in business adoption of Cloud Computing", Industrial Management & Data Systems, 117(1),228-246. https://doi.org/10.1108/IMDS-11-2015-0468

Marco., C. (2011), Cloud Computing technology in Telecommunication ecosystems and recent ITU-T standardization efforts *In International Workshop Innovative research directions in the field of telecommunications in the world*. International Telecommunication Union. Moscow, Russia

Marinos, A. & Briscoe, G. (2009). Digital ecosystems in the clouds: towards community cloud computing. In: IEEE, (corp. ed.) 2009 *3rd IEEE International Conference on Digital Ecosystems and Technologies* . Institute of Electrical and Electronics Engineers (IEEE),pp. 103-108, New York, USA,

Marston, S., Li, Z., Bandyopadhyay, S., Zhang, J. & Ghalsasi, A. (2011). Cloud computing The business perspective. Decision Support Systems. 51 (1),176–189.

Mather, T., Kumaraswamy, S. & Latif, S. (2009). Cloud Security and Privacy. O'Reilly Media.

Mell, P. and Grance, T. (2011). The NIST definition of cloud computing, recommendations of the National Institute of Standards and Technology, Special Publication 800-145. Retrieved from: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf (Accessed 7th October 2019).

Mesgana, W. (2017). Analysis of Datacenter Network Performance with special focus on

Ethio telecom Datacenter. (Unpublished Master's Thesis). HiLCoE school of computer science and technology, Addis Ababa.

Mervat A. B., & Sarfraz N. B.(2011), Exploring the Cloud Deployment and Service Delivery Models, International Journal of Research and Reviews in Information Sciences (IJRRIS),1(3),77-80.

Misra, S.C. and Mondal, A. (2011) Identification of a Company's Suitability for the Adoption of Cloud Computing and Modeling Its Corresponding Return on Investment. Mathematical and Computer Modelling, 53, 504-521. http://dx.doi.org/10.1016/j.mcm.2010.03.037

Mohammad , H. & Rafiqul K. (2018), A Systematic Review on Cloud Computing ,International Journal of Computer Sciences and Engineering, 6(11),632-639

Mohapatra, S. & Lokhande, L. (2014). Cloud Computing and ROI A New Framework for IT Strategy. Springer International Publishing Switzerland.

Moore, G. & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. Information systems research. 2 (3), 192–222.

Morgan, L. & Conboy, K. (2013) 'Factors affecting the adoption of cloud computing: An exploratory study, *In Proceedings of the 21st European Conference on Information Systems*,ECIS.

Mustafa, E., Ibrahim, M., Sadiq, S., & Kashif, J.(2015) Cloud Computing Adoption: A Mapping of service delivery and deployment Models *in The Fifteenth International Conference on Electronic Business, Hong Kong.*

Mustafa, E., Ibrahim, M. & Sadiq, S., (2018), Selection of cloud delivery and deployment models: An expert system approach. International Journal of Decision Support System Technology,10(4) 17-31.

Narayana, E.,Kumar, S. & Jayashree, K.(2017), A Review on Different types of Deployment Models in Cloud Computing, International Journal of Innovative Research in Computer and Communication Engineering, 5(2),1475-1481, DOI: 10.15680/IJIRCCE.2017. 0502029 1475

Naveen, K. (2013). Cloud Application Assessment Toolkit, (Unpublished Project Paper). Indian institute of technology, Hyderabad.

Noor, K.B.M. (2001). Case Study : A Strategic Research Methodology. University Technology Malaysia.

Object Management Group (2019). Practical Guide to Cloud Deployment Technologies Version

1.0., Retrieved from https://www.omg.org/cloud/deliverables/Practical-Guide-to-Cloud-Deployment-Technologies.pdf

Oliveira, T., Thomas, M. & Espadanal, M. (2014). Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors. Information & Management. 51 (5),497-51 Retrieved from https://doi.org/10.1016/j.im.2014.03.006

Olumide, A.A. (2014). Assessment of Cloud Computing Readiness of Financial Institutions in South Africa. University of Cape Town.

Pal, N., & Pantaleo, D. (Eds.). (2005). The agile enterprise: Reinventing your organization for success in an on-demand world. Springer Science & Business Media.

Pauly, M. (2011). T-Systems' Cloud-Based Solutions for Business Applications. *In: A. Goscinski, J. Broberg, & R. Buyya (eds.). Cloud Computing: Principles and Paradigms*. John Wiley & Sons.

Phaphoom, N., Wang, X., Samuel, S., Helmer, S. & Abrahamsson, P. (2015). A survey study on major technical barriers affecting the decision to adopt cloud services. Journal of Systems and Software.103,167–181.

Raj P., Periasamy M. (2011) The Cloud Challenges for Enterprise Architects. *In: Mahmood Z., Hill R. (eds) Cloud Computing for Enterprise Architecture*s. Computer Communications and Networks. Springer, London.

Rahul, M. & Prince,J.(2013),How to choose an economic cloud deployment model. *International Journal of Computer Trends and Technology (IJCTT)*, 4(8), 2607- 2614.

Rao, V., Kamsali, N., & Reena, D. (2016), A New Computing Environment Using Hybrid Cloud." Journal of Information Sciences and Computing Technologies 3 (1), pp. 180-185.

Rimal, B.P., Jukan, A., Katsaros, D. & Goeleven, Y. (2011). Architectural Requirements for Cloud Computing Systems: An Enterprise Cloud Approach. Journal of Grid Computing. 9, 3–26.

Robson, C. (2002). Real World Research: A Resource for Social Scientists and Practitioner-Researchers. 2nd Ed. Wiley.

Rountree, D., Castrillo, I. (2014) The Basics of Cloud Computing, Understanding the Fundamental of Cloud Computing in Theory and Practice, Waltham, USA: Elsevier

Runeson, P. & Höst, M. (2009). Guidelines for conducting and reporting case study research in software engineering. Empirical Software Engineering. 14,131–164.

Ruth L. (2017), Assessment of Ethio Telecom Readiness for the Implementation of Cloud Computing Services (Unpublished Master's Thesis). Addis Ababa University, Addis Ababa.

Sabi, H. M., Uzoka, F. M. E., Langmia, K., & Njeh, F. N. (2016). Conceptualizing a model for adoption of cloud computing in education. International Journal of Information Management, 36(2), 183-191

Sadashiv, N. & Kumar, S.M.D. (2011). Cluster, grid, and cloud computing: A detailed comparison. *In: 6th International Conference on Computer Science & Education* (ICCSE) (pp.477–482). IEEE.

Sailer, A., Head, M.R., Kochut, A., & Shaikh, H. (2010). Graph-Based Cloud Service Placement. *IEEE International Conference on Services Computing*, 89-96.

Sajid, M. & Raza, Z. (2013). Cloud Computing: Issues & Challenges. *In: International Conference on Cloud, Big Data and Trust* (pp. 13–15).

Saripalli, P., & Pingali, G. (2011). MADMAC: Multiple Attribute Decision Methodology for Adoption of Clouds. *In IEEE 4th International Conference on Cloud Computing* (pp. 316-323).

Saunders, M., Lewis, P. & Thornhill, A. (2009). Research Methods for Business Students. 5th Ed. Pearson Education Limited.

Savu, L. (2011). Cloud Computing: Deployment Models, Delivery Models, Risks and Research Challenges, *In International Conference on Computer and Management* (pp. 1-4). Wuhan.

Seifu, S. D., Dahiru, A. A., Bass, J. M. & Allison, I. K. (2017) Cloud-computing: Adoption issues for Ethiopian public and private enterprises. The Electronic Journal of Information Systems in Developing Countries, 78(1), 1–14.

Selamawit, B. (2014). Exploring Factors that Affect the Decision to Adopt Cloud Computing Technology in Ethiopian Banking Sector (Unpublished Master's Thesis). Addis Ababa University, Addis Ababa.

Smoot, S.R., & Tan, N.K. (2011). Private Cloud Computing: Consolidation, Virtualization, and Service-Oriented Infrastructure. Computer and security 31,629.

Stephen O. & Dan O. (2016). Cloud Computing Governance Readiness Assessment: Case Study

of a local Airline Company. International Journal of Applied Information Systems, 10 (8) , 33-42.

Sultan N. & van de Bunt-Kokhuis, S. (2012). Organizational culture and cloud computing:

coping with a disruptive innovation. Technology Analysis & Strategic Management. 24 (2) ,167–179.

Sumit, G.(2014), Public vs Private vs Hybrid vs Community - Cloud Computing: Critical Review, International Journal of *Computer Network, and Information Security,(3)1,20-29*, DOI: 10.5815/ijcnis.2014.03.03

Sun, L., Dong, H., Hussain, F. K., Hussain, O. K., & Chang, E. (2014) 'Cloud service selection: State-of-the-art and Future research directions, Journal of Network and Computer Applications, 45(1), pp. 134-150.

Toosi, A.N., Calheiros, R.N. & Buyya, R. (2014). Interconnected Cloud Computing

Environments. ACM Computing Surveys. 47 (1),1–47.

Trigueros-Preciado S., Perezz-gonzalez D. & Solana-gonzalez P. ,(2013). "Cloud computing in

industrial SMEs : identification of the barriers to its adoption and effect of its application ", Electron Markets, 23,105–114.

Tseng, Y.-H., & Lin, C.-T. (2011). Enhancing enterprise agility by deploying agile drivers, capabilities, and providers. Information Sciences, 181(17), 3693–3708. http://doi.org/https://doi.org/10.1016/j.ins.2011.04.034

Vajda, A., Baucke, S., Catrein, D., Curescu, C., Halén, J., Kempf, J., Lemieux, Y., Melander, B.,

Mohammed, A., Mångs, J., Naslund, M., Shohel, A.M., Ylitalo, J., & Thorelli, S. (2012). Cloud Computing and Telecommunications: Business Opportunities, Technologies, and Experimental Setup. World Telecommunications Congress, 1-6.

Vaquero, L.M., Rodero-Merino, L., Caceres, J. & Lindner, M. (2008). A break in the clouds:

towards a cloud definition. *ACM SIGCOMM Computer Communication Review*. 39 (1) ,50–55.

Venkatesh, V. & Brown, S.A. (2013). Bridging the Qualitative–Quantitative Divide: Guidelines

for Conducting Mixed Methods. *Research in Information Systems*. MIS Quarterly. 37(1),

21–54.

Voorsluys, W., Broberg, J. & Buyya, R. (2011). Introduction to Cloud Computing. *In: R. Buyya,*

J. Broberg, & A. Goscinski (eds.). Cloud Computing: Principles and Paradigms (pp. 3-42) . Wiley.

Wang, K & Lin, Ch. (2012). The adoption of mobile value-added services: Investigating the influence of IS quality and perceived playfulness. Managing Service Quality. 22(2), 184-208. 10.1108/09604521211219007.

Wan, Z. (2010). Sub-millisecond level latency sensitive Cloud Computing infrastructure. International Congress on Ultra-Modern Telecommunications and Control Systems, 1194-1197.

Weinman, J. (2012). Cloudonomics: The business value of cloud computing. John Wiley & Sons .

Williams, B. (2012). The Economics of Cloud Computing: An Overview for Decision Makers. Network Business series. Cisco Press

Yang, X., Wallom, D., Waddington, S., Wang, J., Shaon, A., Matthews, B., Wilson, M., Guo, Y., Guo, L., Blower, J.D., Vasilakos, A. V., Liu, K. & Kershaw, P. (2014). Cloud computing in e-Science: research challenges and opportunities. The Journal of Supercomputing. 70 (1),408–464. Retrieved from: http://link.springer.com/10.1007/s11227-014-1251-5.

Yin, R. K. (2009). Case Study Research Design and Methods (4th ed.). Thousand Oaks, CA Sage Publications.

Young-Chan L.., Hanh, T., & Vijayan ,S. (2012).A Deployment Model for Cloud Computing using the Analytic Hierarchy Process and BCOR Analysis. *In Americas Conference on Information Systems(AMCIS) proceeding paper 18.* Retrieved from http://aisel.aisnet.org/amcis2012/proceedings/EnterpriseSystems/18.

Zardari, S., Bahsoon, R., & Ekart, A. (2014). Cloud Adoption: Prioritizing Obstacles and Obstacles Resolution Tactics Using AHP. In Requirements Engineering Track, The 29th ACM Symposium on Applied Computing, Gyeongju, Korea. Retrieved from http://www.cs.bham.ac.uk/~sxz845/Obstacles-AHP.pdf

Zhang, Q., Cheng, L. & Boutaba, R. (2010) Cloud Computing: State of the Art and Research Challenges. Journal of Internet Services and Applications, 1, 7-18.

Zhou, W., Xiao, Y., & Shen, Y. (2014). Application of Cloud Computing in Telecom Operators. Computer System Networking and Telecommunications 1(1). doi:10.18063/csnt.v1i1.544

Zhu Y. (2017), Cloud Computing: Current and Future Impact on Organizations.(Unpublished master theses),Western Oregon University Retrieved from https://digitalcommons.wou.edu/computerscience_studentpubs/4

Appendix A: Interview question for Model Inputs

1. What are the ICT services and supports that are provided for internal and external users of Ethio telecom by your office?
    a) For internal users, employees, and management staff?
    b) For external users, customers, partners, and suppliers?
2. Do you think these services are enough to achieve your mission and vision, in improving quality service to customers, reducing cost and IT complexity, optimizing ICT usage efficiently, dynamic scalability of resources, increasing competitive advantage and modernizing your company?
3. What are the limitations in providing an efficient ICT services?
4. How would you describe the degree of automation in your current IT-Infrastructure?
5. What do you recommend for solving to the above-mentioned limitation of the service?
6. What are the feedbacks of the users about your ICT service? Positive and negative? Why?
7. What is your suggestion in formulating a new paradigm for providing ICT services and supports in the Ethio telecom? And if possible, suggest your own solution from the current technology trends?
8. Do you think cloud computing can solve the problem you mention earlier ?

Appendix B : Expert's Model Evaluation form

Dear Participant, the objective of this form is to validate and evaluate the proposed cloud deployment model. Based on the give cloud deployment model please evaluate the model based on the below questions. The information is extremely important for the success of the thesis and to achieve its objectives. Hence, I would like to ask you to fill the form honestly and promptly.

1. How did you find the proposed cloud deployment model ?

   _____

   _____

   _____

   _____

   _____

   _____

   _____

2. Do you think the proposed cloud deployment model fit Ethio telecom needs ? How?

   _____

   _____

   _____

   _____

   _____

   _____

3. Do you think it will solve current limitation of Ethio telecom service or application if the proposed model implemented ?

   _____

   _____

   _____

   _____

   _____

   _____

   _____

4. Do you think the proposed model will achieve your organization mission and vision, in improving quality service to customers, reducing cost and IT complexity, optimizing ICT usage efficiently, dynamic scalability of resources, increasing competitive advantage and modernizing your company?

_____
_____
_____
_____
_____
_____
_____

5. Do you have any other recommendation or feedback on the proposed model?

_____
_____
_____
_____
_____
_____
_____

Appendix C : Survey for Identifying Application and service

Dear Participant, my name is Almehadi Ali, I am a postgraduate student at Addis Ababa University school of Information Science. Currently, I am doing a master's thesis as part of partial fulfillment of the requirements for the Degree of Master of Science in Information Science with a title "**A Cloud Computing Adoption Framework for Ethio telecom".** The objective of this questionnaire is to collect data from Ethio telecom staffs, to identify IT application and service in Ethio telecom.

Your response is only for academic purpose and all information will remain confidential and will be used for academic purpose only. The information is extremely important for the success of the thesis and to achieve its objectives. Hence, I would like to ask you to fill the questionnaire honestly and promptly.

If you need any clarification or there exist any unclear issue, please do not hesitate to contact me at the number and email below.

I would like to thank you in advance for your cooperation.

Regards,
Almehadi Ali
Email: alme9898@gmail.com
Phone: 0941170747

Part 1: Demographic Questions

Please select the answer by putting tick sign (√) on the appropriate space provided.

1. Please indicate your role in your organisations: Please tick one answer:
   - ☐ Staff
   - ☐ Expert
   - ☐ Manger
   - ☐ Director
   - ☐ Other

2. How long have you been working in organisations? Please tick one answer:
    - Less than 2 years
    - Between 2 and 5 years
    - Between 5 and 10 years
    - More than 10 years
3. Are you familiar with Cloud computing?
    - Yes
    - No

Part 2: IT Application and Service Assessment

1. Can you mention application or service you use in your daily activities? you know or managed by your respective division and organizations ?

_____
_____
_____
_____
_____
_____
_____
_____

2. Can you mention application or service you know or managed by your respective division and organizations ?

_____
_____
_____
_____
_____
_____
_____
_____

Appendix D : Survey for Cloud readiness Assessment

Dear Participant, my name is Almehadi Ali, I am a postgraduate student at Addis Ababa University school of Information Science. Currently, I am doing a master's thesis as part of partial fulfillment of the requirements for the Degree of Master of Science in Information Science with a title "**A Cloud Computing Adoption Framework for Ethio telecom".** The objective of this questionnaire is to collect data from Ethio telecom staffs, to investigate the readiness level of Ethio telecom to adopt the proposed cloud deployment model.

Your response is only for academic purpose and all information will remain confidential and will be used for academic purpose only. The information is extremely important for the success of the thesis and to achieve its objectives. Hence, I would like to ask you to fill the questionnaire honestly and promptly.

If you need any clarification or there exist any unclear issue, please do not hesitate to contact me at the number and email below.

I would like to thank you in advance for your cooperation.

Regards,

Almehadi Ali
Email: alme9898@gmail.com
Phone: 0941170747

Part 1: Demographic Questions

Please select the answer by putting tick sign (√) on the appropriate space provided

1. Please indicate your role in your organisations: Please tick one answer:
   - Staff
   - Expert
   - Manger
   - Director
   - Other
2. How long have you been working in organisations? Please tick one answer:
   - Less than 2 years
   - Between 2 and 5 years
   - Between 5 and 10 years
   - More than 10 years

Part 2: Readiness Assessment

Please carefully read each question and select the answer by putting tick sign (√) on the appropriate services based on the requirement.

1. Which of the following IT service or application in your organization significantly contribute to turnover and profit to your organization?

   ☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
   ☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
   ☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
   ☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
   ☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
   ☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
   ☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
   ☐Unstructured Supplementary Service Data (USSD)

2. Which of the following IT service or application in your organization allows your organization to gain competitive advantage in terms of innovations, business process speed and agility?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

3. Which of the following IT service or application in your organization significantly important for core business processes to run or if the IT service not available, the core business cannot run?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☒IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

4. Which of the following IT service or application in your organization that requires high availability or can be delivered without interruption?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

5. Which of the following IT service or application in your organization that have strong integration into other systems and have dependencies to other processes?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

6. Which of the following IT service or application in your organization that are not adopted or customized to company needs?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

7. Which of the following IT service or application in your organization that have central administration structure in terms of management task related to the service?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

8. Which of the following IT service or application in your organization that have global technical administration where hardware and software are centrally provided and configured?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

9. Which of the following IT service or application in your organization that have low bandwidth requirement?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

10. Which of the following IT service or application in your organization that have low latency sensitivity?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

11. Which of the following IT service or application in your organization that have its own identity management independent from Ethio telecom active directory ?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

12. Which of the following IT service or application in your organization, that have follows central guidelines for provisioning and de-provisioning of users including conventions for naming and security?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

13. Which of the following IT service or application in your organization that have requires an extensive organizational and technical efforts?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

14. Which of the following IT service or application in your organization that require a processed data to match strict legal and regulatory standards, or company-specific compliance standards including security?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

15. Which of the following IT service or application in your organization that that utilizes IT resources with a utilization that grows or shrinks constantly overtime experience?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service
☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)
☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting
☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)
☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message
☐Unstructured Supplementary Service Data (USSD)

16. Which of the following IT service or application in your organization that have a division between stateful and stateless components or layered as data layer, presentation layer and logic layer?

☐Intranet ☐Yimulu ☐Ethio Mail ☐ISP -Email service

☐IPCC- Gebeta ☐ISP- DNS ☐Etopup ☐IP Contact Center (IPCC)

☐Voice mail service ☐MVAS Anti-Spam ☐ISP - Web hosting

☐Enterprise Resource Planning (ERP) ☐Convergent Billing System (CBS)

☐Customer Relationship Management (CRM) ☐Electronic customer accusation form(Ecaf)

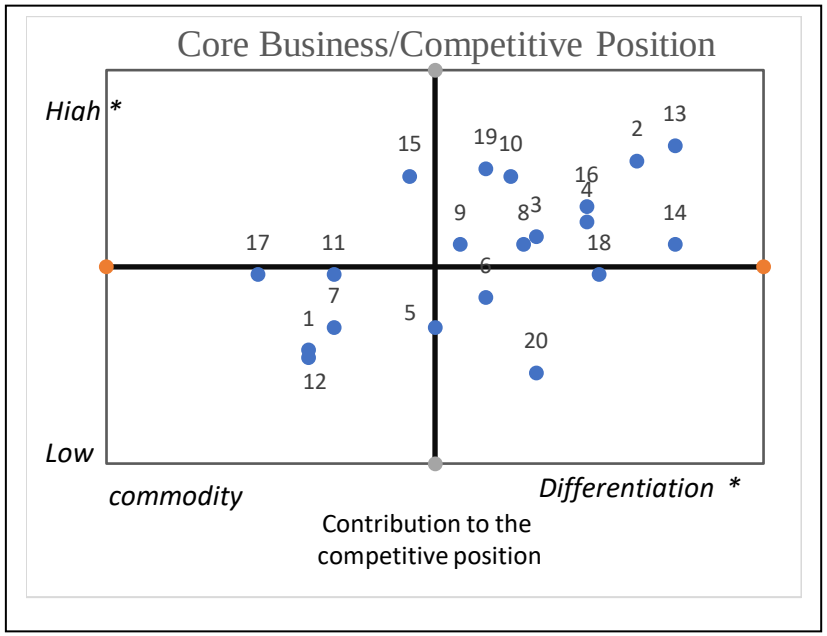
☐Short message service center (SMSC) ☐Multimedia Messaging Service Center (MMSC)

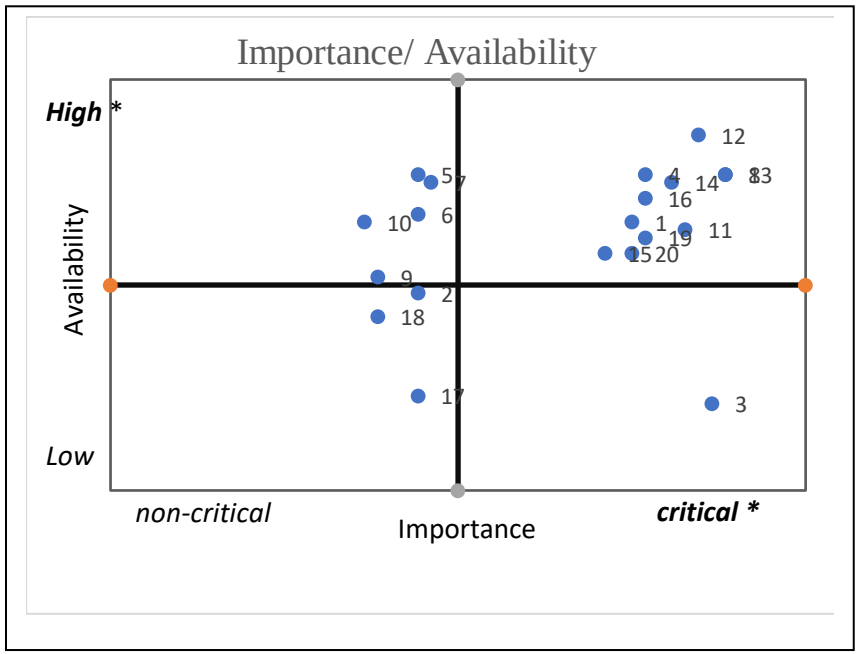
☐Caller Ring back Tone (CRBT) ☐MVAS - Roaming Welcome Message

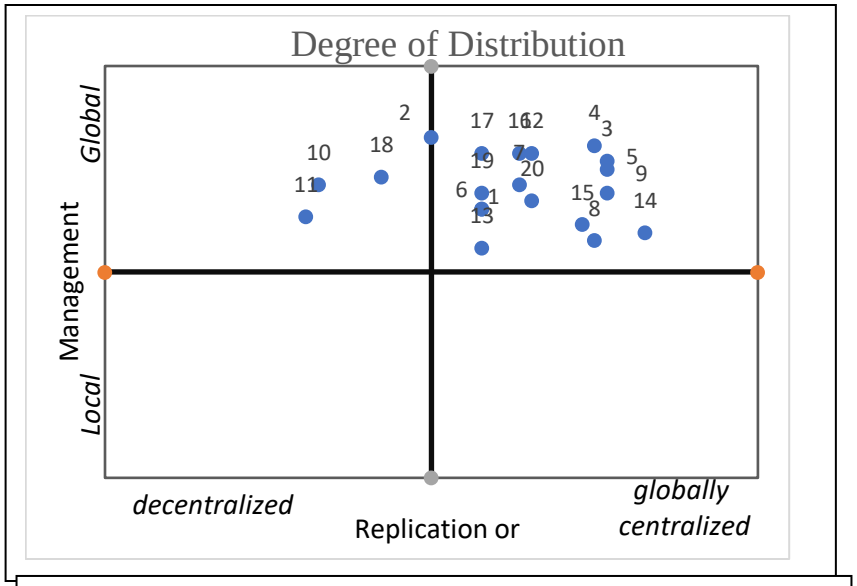
☐Unstructured Supplementary Service Data (USSD)

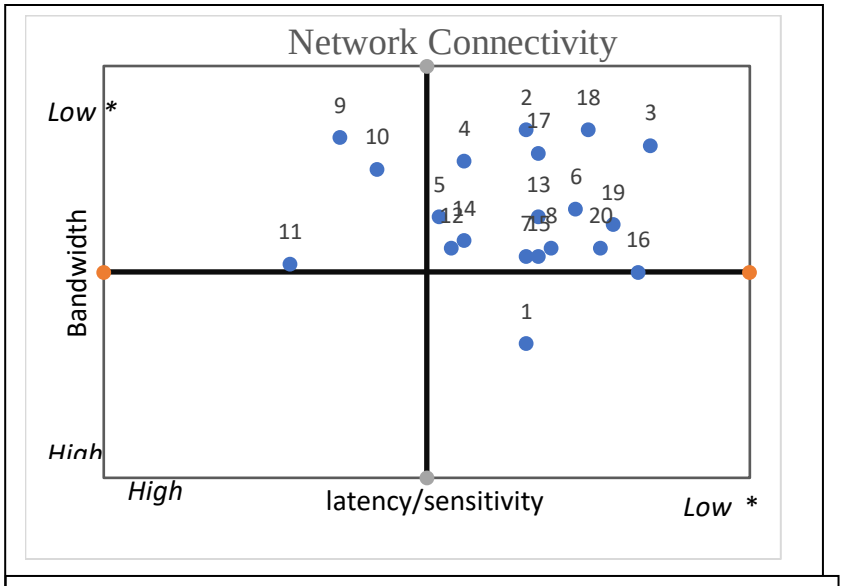
Appendix E : A Magic Matrix evaluation for criterion

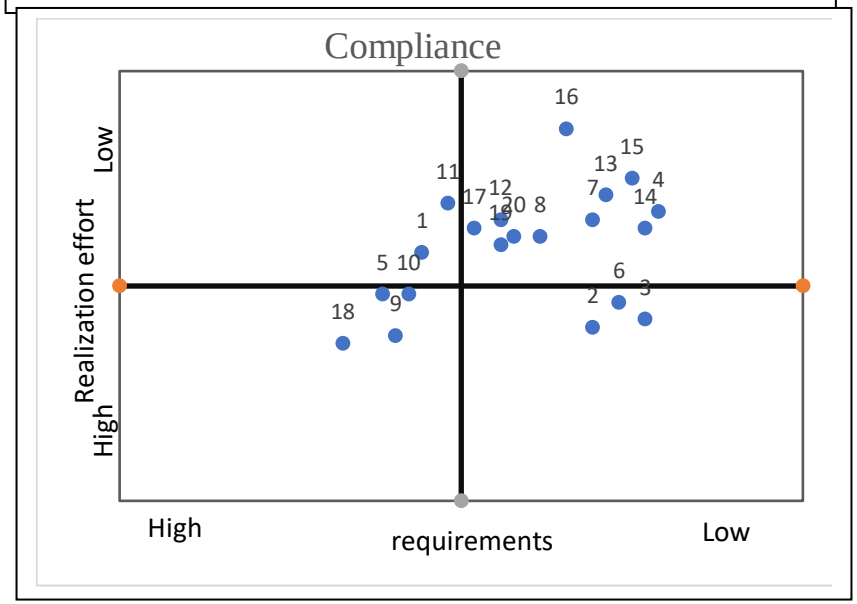
Key: 1. Intranet 2. Yimulu 3. Etopup 4. IPCC- Gebeta 5. ISP- DNS 6. Ethio Mail 7. IP Contact Center (IPCC) 8. Voice mail service 9. ISP - Web hosting 10. ISP -Email service 11. MVAS Anti-Spam 12. Enterprise Resource Planning (ERP) 13. Convergent Billing System (CBS) 14. Customer Relationship Management (CRM) 15. Electronic customer accusation form(Ecaf) 16. Short message service center (SMSC) 17. Multimedia Messaging Service Center (MMSC) 18. Caller Ring back Tone (CRBT) 19. MVAS - Roaming Welcome Message 20. Unstructured Supplementary Service Data (USSD)

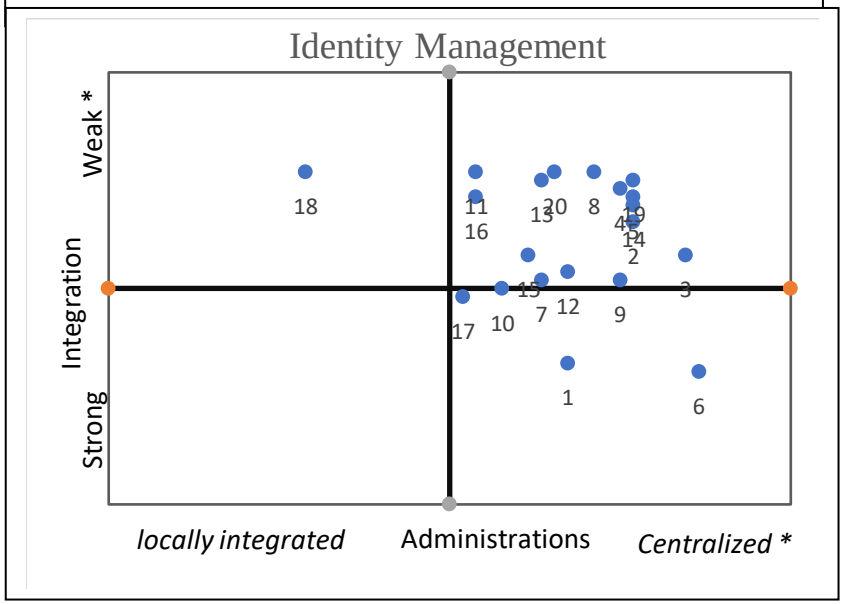


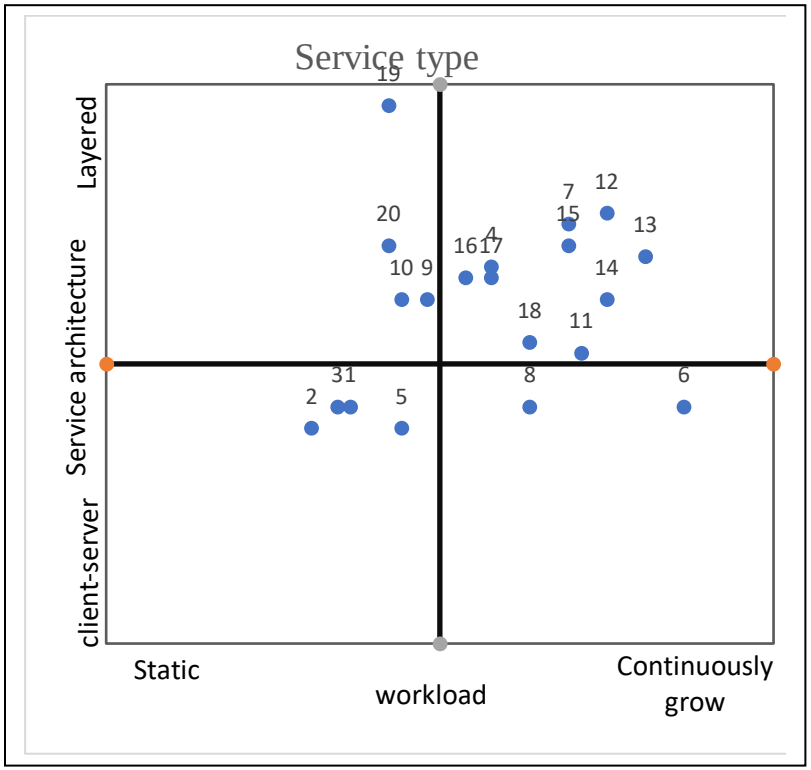


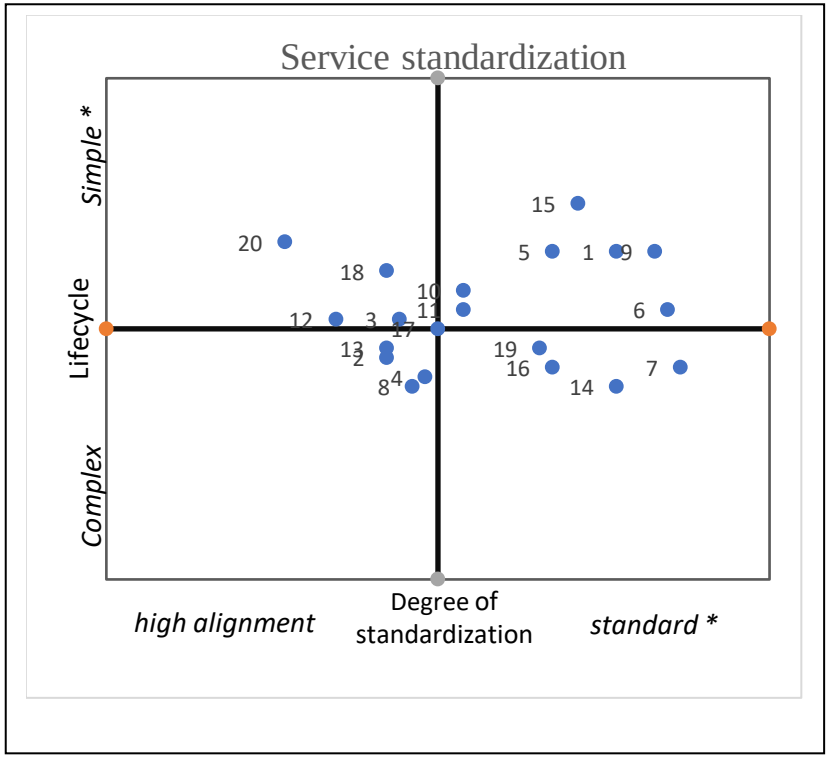

Degree of Distribution
Global
Management
Local
decentralized
Replication or
globally
centralized


Network Connectivity
Low *
Bandwidth
High
High
latency/sensitivity
Low *


Compliance
Low
Realization effort
High
High
requirements
Low

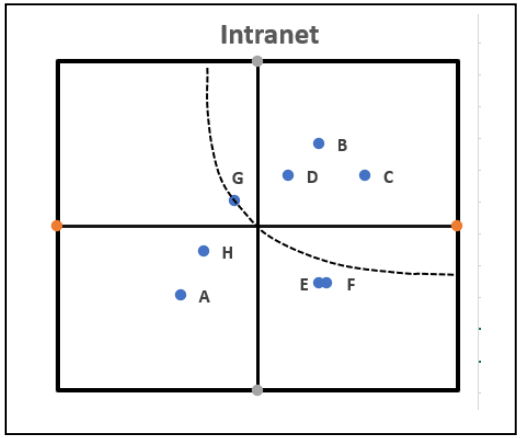

Identity Management
Weak *
Integration
Strong
locally integrated
Administrations
Centralized *

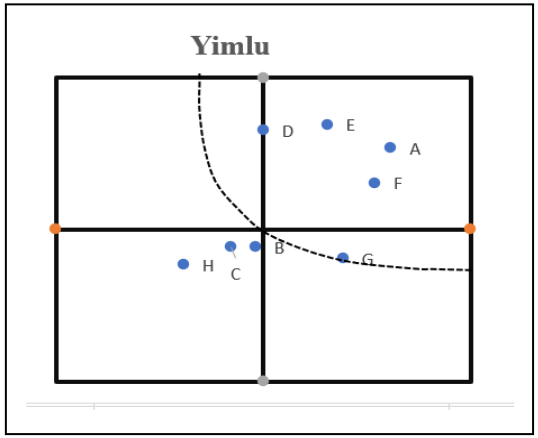

Service type
Layered
Service architecture
client-server
Static
workload
Continuously
grow

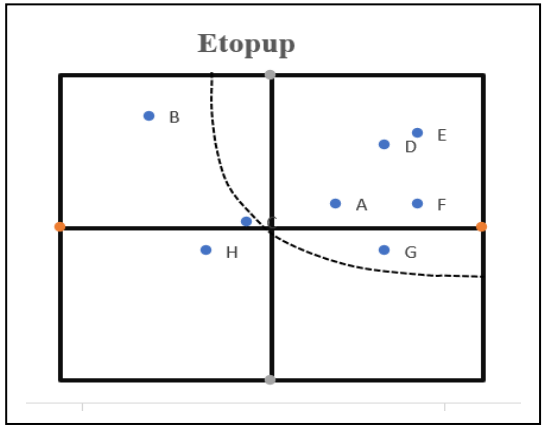

Service standardization
Simple *
Lifecycle
Complex
high alignment
Degree of
standardization
standard *

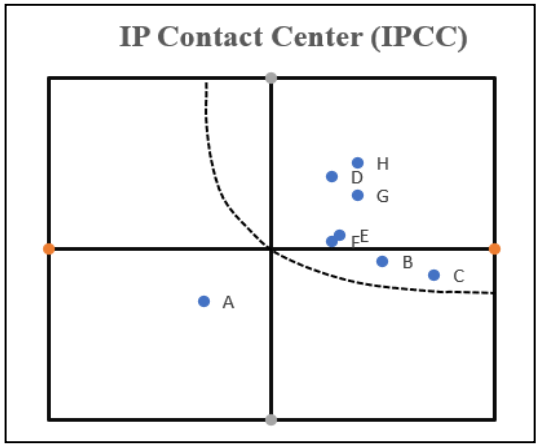
Appendix F : A Magic Matrix evaluation for IT Service and Application

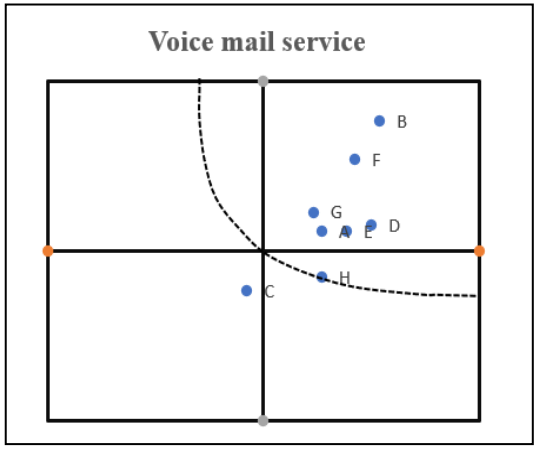
Key : A - Core Business / Competitive Position B - Importance / Availability C – Standardization D- Degree of Distribution E - Network Connectivity F - Identity Management G – Compliance H-- Service type

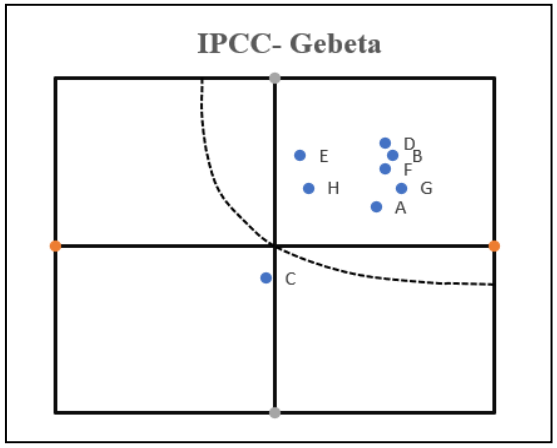


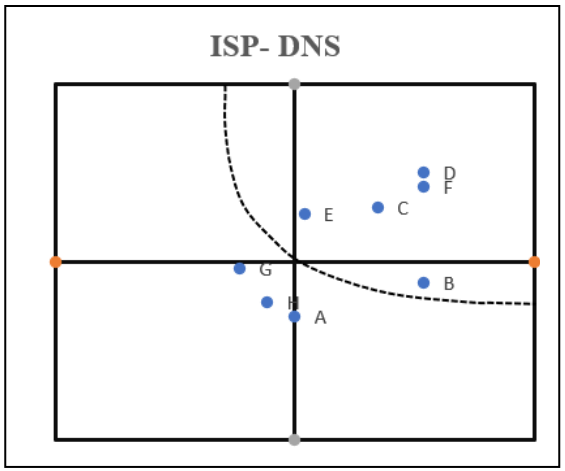


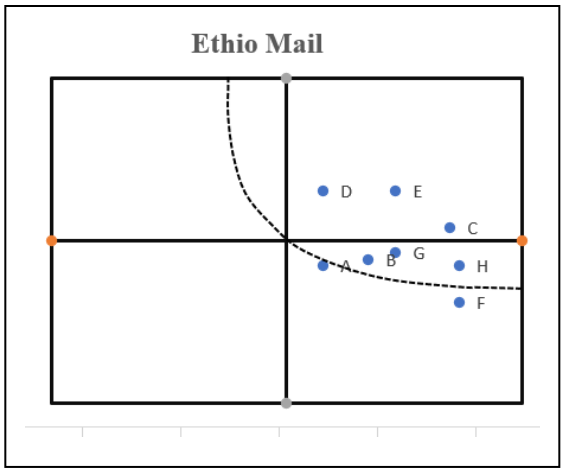


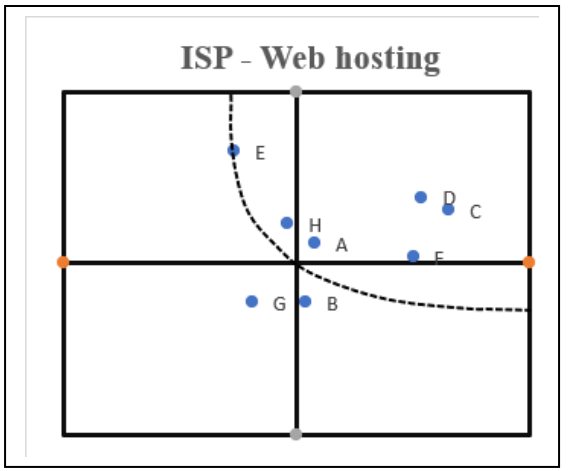


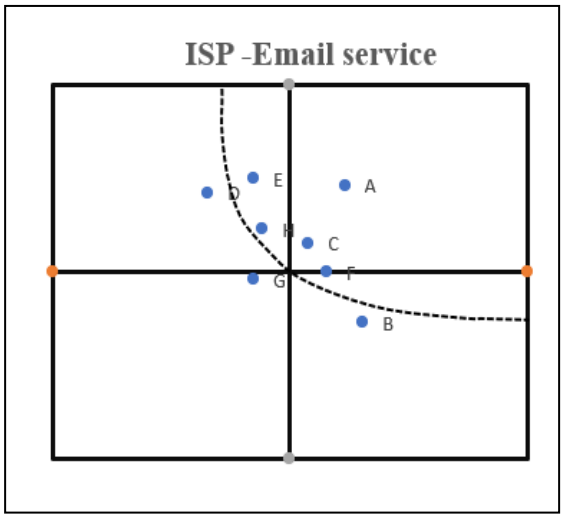


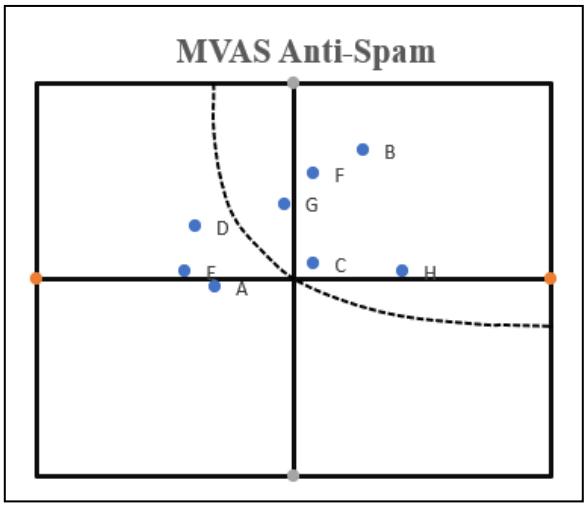


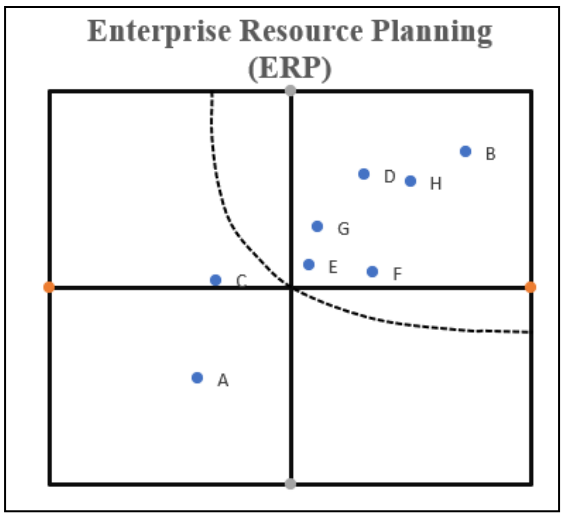

ISP- DNS
D
F
E
C
G
B
H
A

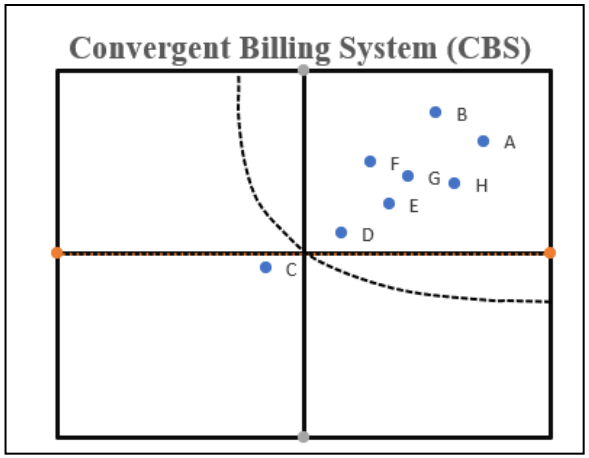

Ethio Mail
D
E
C
G
B
A
H
F

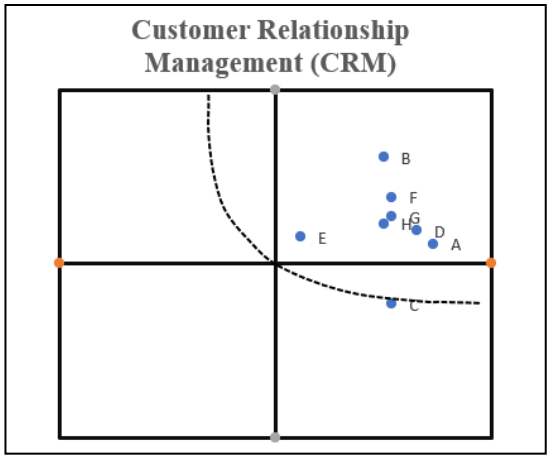

ISP - Web hosting
E
D
C
H
A
F
G
B

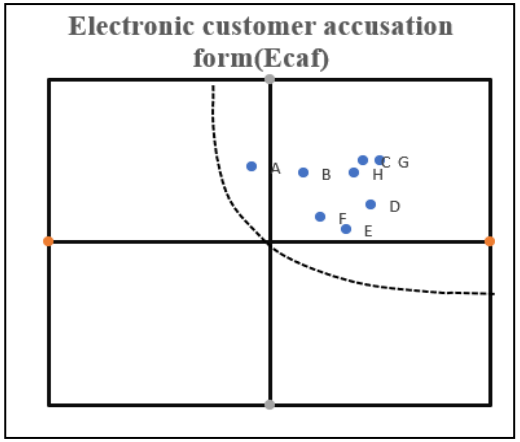

ISP -Email service
E
A
D
H
C
F
G
B

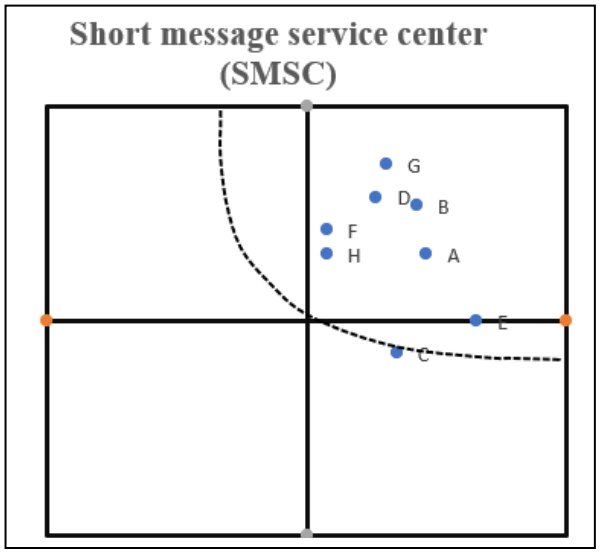

MVAS Anti-Spam
B
F
G
D
E
C
H
A

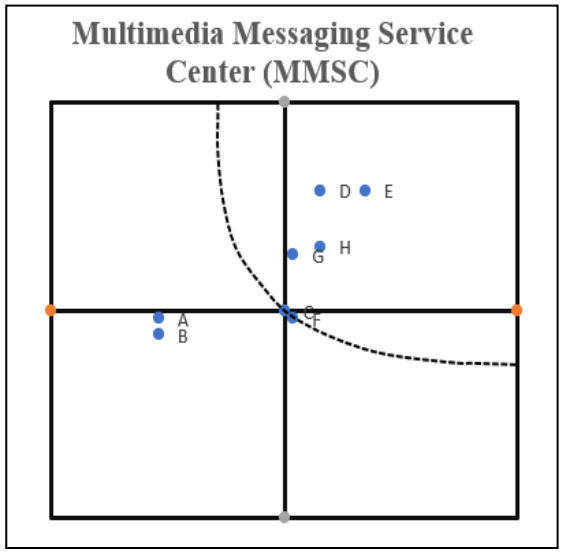

Enterprise Resource Planning (ERP)
B
D
H
G
E
F
C
A

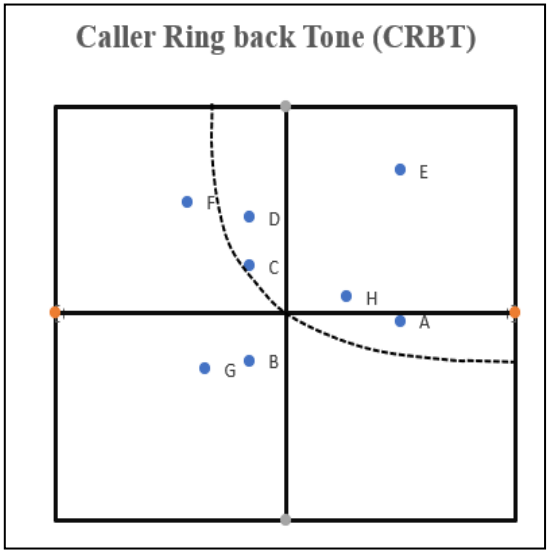

Convergent Billing System (CBS)
B
A
F
G
H
E
D
C

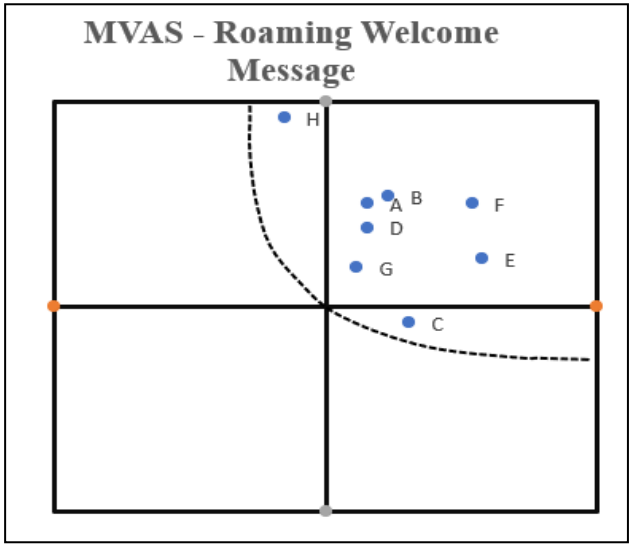

Customer Relationship Management (CRM)
B
F
G
H
D
A
E
C

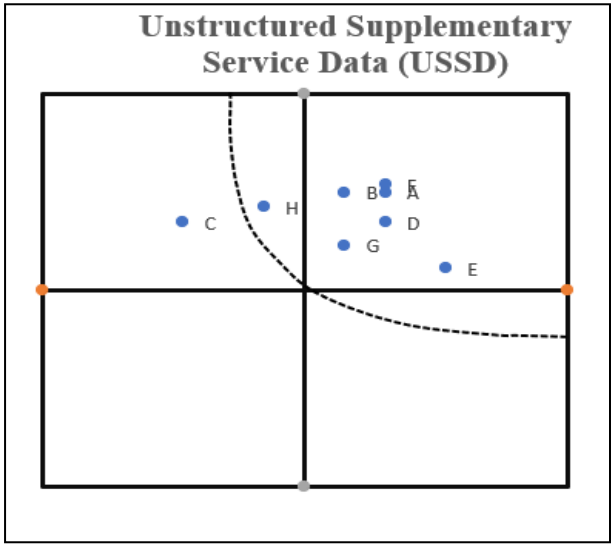

Electronic customer accusation form(Ecaf)
A
B
H
C
G
D
F
E


Short message service center (SMSC)
G
D
B
F
H
A
E
C


Multimedia Messaging Service Center (MMSC)
D
E
H
G
A
B
C
F


Caller Ring back Tone (CRBT)
E
F
D
C
H
A
G
B


MVAS - Roaming Welcome Message
H
A
B
F
D
G
E
C


Unstructured Supplementary Service Data (USSD)
C
H
B
A
D
G
E

አዲስ አበባ ዩኒቨርሲቲ
የተፈጥሮ ሳይንስ ኮሌጅ
የኢንፎርሜሽን ሳይንስ ት/ቤት

ADDIS ABABA UNIVERSITY
College of Natural Science
School of Information Science

Date: January 27, 2020
Ref No. SIS/35/2020/2012

28 JAN 2020

To:- Ethiotelecom
Addis Ababa

Subject:- Student Almehadi Ali

Dear Sir /Madam,

Student Almehadi Ali (ID.No GSE/2417/10) is graduate student at the School of Information System, Addis Ababa University. He is currently conducting a MSc. Thesis research under the title "Cloud Computing Framework for Ethiotelecom".

I would like to thank you in advanced for all the assistance that you would provide to the student.

With Regards

Tibebe Beshah (PhD)
Head, School of Information Science

SCHOOL OF INFORMATION SCIENCE * ADDIS ABABA UNIVERSITY *

✉: 1176 Email: information_cci_cns@aau.edu.et ☎: +251-(11)-122-91-91