ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTING

A CLOUD COMPUTING FRAMEWORK FOR ETHIOPIAN SMALL AND MEDIUM ENTERPRISES

BY:

MELESE TEZERA HABTE

ADVISOR:

MANOJ V.N.V (Ph.D.)

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DEPARTMENT OF COMPUTING

A CLOUD COMPUTING FRAMEWORK FOR ETHIOPIAN SMALL AND MEDIUM ENTERPRISE

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Approved by the board of Examiners and Advisor:

_____	_____	_____
Advisor	Signature	Date
_____	_____	_____
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_____	_____	_____
Internal Examiner	Signature	Date
_____	_____	_____
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School Dean	Signature	Date

Declarations

This research work is my original work and has not been presented or submitted for the award of any other degree or diploma at any university.

Signature: - _____

Date: - _____

Melese Tezera

CONFIRMED BY ADVISOR

Signature: - _____

Date: - _____

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List of Acronyms and Abbreviations

SMEs	Small and Medium-Sized Enterprises
ICT	Information and communication technology
IT	Information Technology
CC	Cloud computing
EC2	Elastic Compute Cloud
EBS	Elastic Block Service
S3	Amazon's Simple Storage Solution
IaaS	Infrastructure as a Service
PaaS	Platform as a Service
SaaS	Software as a Service
FMaSE	Ethiopian Federal Micro and Small Enterprises Agency
CRM	Customer Relationship Management
SCM	Supply Chain Management
ERP	Enterprise Resource Planning
EthERNet	Ethiopian Education and Research Network
DSRM	Design Science Research Methodology
VM	Virtual Machine
SLA	Service Level Agreement
NIST	National Institute of Standards and Technology
VPN	Virtual Private Network
SOA	Service Oriented Architecture
RA	Reference Architecture
RM	Reference Model
SMT	Multi-Tenancy stack
VDI	Virtual desk-top infrastructure

CCRA	Cloud Computing Reference Architecture
TAM	Technology Acceptance Model
TOE	Technology Organization Environment
ESMEHC	Ethiopian Small and Medium Enterprise Hybrid Cloud
OCA	Open Nebula Cloud API
CC	Cluster Controller
SC	Storage Controller
NC	Node Controller
NASA	National Aeronautics and Space Administration
QoS	Quality of Service
OCCI	Open Cloud Computing Interface
XML	Extensible Markup Language
Hyper-V	Windows Server Virtualization
KVM	Kernel-based Virtual Machine
QEMU	Quick Emulator (Emulates a full system)
UML	Unified Modeling Language
OVF	Open Virtualization Format
Op-ex	Operating expenses
Cap-ex	Capital expenditures
WSDL	Stands for Web Services Description Language
SOAP	Simple Object Access Protocol
UDDI	Universal Description, Discovery, and Integration
EICTDA	Ethiopian ICT Development Agency
MCIT	Ministry of Communication and Information Technology
SDPRP	Sustainable Development and Poverty Reduction Program
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
RPC	Remote Procedure Calls

Abstract

Nowadays in Ethiopia, there are expansions of ICT infrastructure and services. These technologies are used to access and communicate information and also it closely linked to the economic growth of the country. However, the significance of Information and Communication Technologies (ICT) to the growth of SMEs were not given the required level of attention in the country. Due to this, the adoption of the latest information technology by SMEs in Ethiopia is below the expected level. This research has examined and attempted to address the problem surrounding the low level of adoption and usage of latest information technology in the SMEs sector in Addis Ababa, Ethiopia. Thus, this study was to propose a solution for the problem of low level of utilization of the latest information technology based service through cloud computing technology. The aim of the study was to develop cloud computing framework for Ethiopian SMEs.

This research work used the Design Science Research Methodology (DSRM), which is often used to address IT and organizational problems. It also utilized data collected through interviews conducted face-to-face with SMEs managers that used basic ICT for their business operations in Addis Ababa city.The study applied comparative qualitative analysis techniques. Thus, this study indicated that the Ethiopian SMEs have low knowledge to adopt this new technology.

The research identified and conclude that cloud computing is the better latest information technology utilization mechanism for SMEs. This is because first it enhances the productivity and effectiveness of certain activities or functions made by SMEs.Second, it enables the wise and strategic use of information technology which significantly reduced cost. Accordingly, the research proposed the implementation of Hybrid Cloud Computing model for SMEs. It expected that the adoption of this model will provide significant contribution to the economic growth of the country. The research further recommended in-depth analysis on multiple dimensions of adopting cloud computing to SMEs sector beyond cost effectiveness and facilitation of their business operation. It also recommended additional study on security architecture of virtual data centers in cloud environment for these SMEs.

Keywords: *Small and medium sized Enterprises, Information and communication technology, Cloud Computing*

1. Chapter One: Introduction

This chapter provides an overview of the research. It starts by providing research background and continues by discussing the research motivation, the aim of the study, the methodology adopted, and significance of the research. Finally, concludes with an outline of the thesis structure.

1.1 Background of the study

Nowadays, both large organizations, small and medium-sized enterprises (SMEs) are looking for ways to reinforce their competitive position and improve their productivity [2]. One of the major developments of our time that could provide the means for such competitive environment to facilitate business operation is Information and communication technology (ICT). So that ICT is a key driver of business strategy if survival and growth are critical to the enterprise [3]. A research has tried to conduct, particularly the role of ICT in sub-Saharan Africa's developing countries, particularly in Ethiopia by Yasin Ali Hassen [4].The findings of his study showed that small enterprises in the country are on a very low level of utilizing ICT and e-commerce due to several reasons, among which are scarce in infrastructure development and expertise in the area coupled with barriers from government policy. In general, the previous studies indicated that the challenges of ICT utilization and implementation in most small and medium enterprise in developing countries are related either to financial issues, low infrastructure, legal issues or low IT knowledge [5] [6].

Adoption and use of appropriate technologies can lead organizations to greater business competency, improve its business performance, ensure and keep its competitive advantages. Additionally, such technologies that can help for SMEs to become more efficient [7] . One of the appropriate technologies is cloud computing that affords organizations the opportunity to access on-demand IT services using Internet technologies on a free or pay-per-use basis, thus enabling them to improve their strategic and technological agility and responsiveness in the global business environment [8]. Hence, it reduces the investment, operation and maintenance costs.

Cloud computing is a concept of computing in which dynamically scalable and often virtualized resources (hardware and software) are provided as a service over the Internet [9]. According to [10] Cloud computing represents a fundamental change in the way Information Technology (IT) services are invented, developed, deployed, scaled, updated, maintained and paid for. In cloud computing, cloud users rent applications and infrastructure from cloud providers on a pay-as-you-need basis, this means that cloud users only pay to cloud providers for the services used in specific time [11].

Cloud computing has some unique key features that attract the attention of decision makers to leverage this technology in addressing their concerns over IT implementation. Stated below are some of these key features of cloud computing [12].

- **High performance:** Supercomputing power, large capacity of data storage, and powerful data analysis capability.
- **Flexibility and dynamic scalability:** IT resources could be distributed or redistributed automatically with the increase or decrease of business volume.
- **Low-cost:** Costs are lowered and resource utilization rate is increased owing to centralized allocation, management, and maintenance of IT physical and software resources.
- **Ubiquitous:** Users can access systems through the network; regardless of users' location or the kind of device they are using (e.g. PC, mobile phone, or PDA).
- **Reliability**: Cloud computing has professional teams in place for better security and maintenance.

Therefore, these are numerous benefits of adopting and use cloud services in SMEs is supporting or taking care of their needs of IT solution. These help to better see the organizations think about cloud computing services. Although, there are many studies that analyzed about cloud computing adoption in various countries, according to [13] analyzed "most of the research work so far focused on technical issues of cloud computing". Some researchers, [14] analysis carried out in which cloud computing adoption for SMEs is evaluated, consequently, the results of the analysis indicated that SMEs can make progress dramatically in their business trends through cost reduction structure and faster software upgrade.

Today there are several different cloud service models that are available. In this regard, each country must be considered to be studied as enterprise case, which means a cloud service model for that enterprise. Although some concepts of Cloud Computing will be generic, some of the concepts will be different due to the variety of the contexts of the country. Thus, the ultimate goal of this study would be proposed framework of cloud adoption. This framework will encourage and accelerate the adoption of cloud computing among the enterprises. Finally, this research represents a contribution to the body of knowledge in acceptance of cloud computing regarding the adoption process of cloud computing service.

1.2 Key Terms and Definitions

1.2.1 What are Small and Medium Sized Enterprises (SMEs)?

The term SME's universally stands for small and medium-sized enterprises but there is no internationally agreed and accepted definition of SMEs. This is because definition varies from country to country and usually depends on social and economic growth level of the country.

SMEs vary in size, age, sector, motivation, mode of organization, ethnic background, location, knowledge base, power and control of resources and innovative capacity [15]. According [16] to SME is a firm that employs a maximum of 250 people. [17] Confirm that each country tends to derive its own definition based on the role SMEs are expected to play in that particular economy. SMEs are defined for this study by adopting the definition given 2011 by Ethiopian Federal Micro and Small Enterprises agency (FMaSE) [18]: These are

- **Small Enterprise**s those enterprises hired 6 up to 30 employees or total asset amount birr 100,000 up to 1.5 million birrs for industry sector and 50,000 up to 500,000 not greater than for services sector.
- **Medium Enterprise** is enterprises found in manufacturing and service sectors of the Ethiopian economy with a total asset more than 1.5 million birrs and a total asset of more than birr 500,000 [19].

1.2.2 Information and Communication Technology (ICT)

ICT is defined as any technology that facilitates communication and assists in capturing, processing and transmitting information electronically [20]. In this research, ICT is also regarded as the application of software used to serve major business functions including accounting and human resources' software, customer relationship management (CRM) and supply chain management (SCM), internal IT usage such as Internet and email as well as enterprise resource planning (ERP) that integrates all business functions into a single computer system.

According to [21], ICT comprises different technologies such as computers, the internet, and websites as well as fixed-line telephones, mobile phones and other wireless communication devices, networks, broadband and various specialized devices.

1.3 Research Motivation

In developing countries, small and medium enterprises (SMEs) are an engine for growth and they play an important role in poverty reduction by providing employment and driving economic development and ICT can be used as a tool [22] .However, like as many of the developing countries, the level of utilizing ICT in Ethiopian SMEs considered as low [4]. Since many of SMEs still operate using traditional-based approaches rather than adopting modern technologies.

Cloud computing, its services and deploying models, offers the opportunity for small businesses by subscribing to the pay-per-use method at an affordable price to access infrastructure, platform and software over the Internet [23]. Therefore, by adopting could serve, SMEs may focus on their business process instead of on how to build, maintain, and manage their IT infrastructures.

1.4 Statement of the Problem

The ICT sector in Ethiopia has seen substantial growth over the last decade [24].This technology is used to access and communicate information and closely linked to the economic growth of the country. Consequently, according to [1], in Ethiopia different initiatives are working as part of a national capacity building program that includes National Data Center, Regional Data Center, WoredaNet, School Net, Ethernet, AgriNet that aims to provide connectivity and specialized applications for schools and for local governments.

> *"The Ethiopian Government has made the development of information and communications technology (ICT) one of its strategic priorities. The endorsed and currently enforce ICT policy is a demonstration of its commitment to the development of ICT both as an industry and as an enabler of socio-economic transformation. The policy stems from the recognition by the Government of ICT as the key driver and facilitator for transforming Ethiopia's predominantly subsistence agriculture economy to an information and knowledge-based economy and society, effectively integrated into the global economy. The government has continued to invest in the communications infrastructure to meet this growing demand. Ethiopia has also been working towards stimulating the demand for the underlying infrastructure by increasing access to the public sector network"* [24].

All organizations in today's world should adopt the latest information technology to be competitive for sustainability and growth. However, adoption of the latest information technology by SMEs in Ethiopia is low. Consequently, they are not competitive in the globe and rarely to improve their productivity. Additionally, in traditional IT environments, increasing the complex management issue of software, hardware and networking equipment require specialist staff for implementing and maintaining IT services. Such problems that mention in the above need close attention. In summary, the following constraints identified from previous research work in existing conditions of ICT in Ethiopia on small business [4]: These are

- Lack of reliable and cost-effective IT infrastructure
- Inability to identify company and industry-specific needs

Thus, these situations give more motivation for commencing to propose a framework for adopting latest Information Technology (IT) through cloud computing technologies. These are based on the SMEs business requirements in the context of Addis Ababa, Ethiopia. So that the proposed a framework for cloud adoption from the perspective of cloud-based service delivery architecture considered. Defining a robust and scalable architecture is key to the success of cloud computing implementations, because of it provides a means of communication and coordination between the cloud service providers and the users [25] .

To address the problem for the above mentioned, the following research questions were formulated and answered with the result obtained at the end of the study.

1: How can traditional IT help for Ethiopian SMEs in the current situation of their business operation?

2: Are the current ICT infrastructure and service delivery strategy efficient for SMEs in Ethiopia?

3: How a SMEs can choose the most suitable option for any specific application or service to gain benefits into latest information technology particularly cloud computing?

1.5 Objectives of the Study

1.5.1 General Objective

The general objective of the study is to develop cloud computing framework for Ethiopian SMEs.

1.5.2 Specific Objectives

In order to achieve the general objective, the following specific objectives are identified.

- To examine the current ICT usage and practice in Ethiopian SMEs.
- To review the related literature to identify and understand cloud computing adoption strategy for the small and medium enterprise.
- To develop cloud-based service delivery architecture that can provide cloud service for SMEs.
- To develop a prototype and to simulate the result and show directions for future work.

1.6 Methodology of the Study

The research used qualitative research approach, due to its characteristics. So that in order to achieve the general and specific objectives of the study and answer the research questions, the study followed the research model based on well-accepted elements of the Design Science Research Methodology (DSRM) process [26].

The construction and evaluation of the designed artifacts follow a sequential order, illustrated in Figure 1. This process is iterative and is divided into five different steps, which are explained below.

1. **Problem identification and motivation**: Defines a specific research problem and justifies the value of a solution. Our research problem becomes that adoption of the latest information technology by SMEs in Ethiopia is low. Consequently, they are not competitive in the globe and rarely to improve productivity and performance of an organization. The following constraints identified from previous research work in existing conditions of ICT in Ethiopia on small business [5]: These are
    - Lack of reliable and cost-effective IT infrastructure
    - Inability to identify company and industry-specific needs
2. **Objectives of a solution**: The objective of the solution helps to efficiently utilize the potential of cloud computing as the latest information technology, these are formulated and used as the direction and representation of the intended objectives of this research.
3. **Design and development**: It started with examined the collected as well as analyzed data. Also, concepts from various literature such as cloud adoption strategy are reviewed and combined into a comprehensive workflow in order to lead adopt and use cloud computing in an enterprise. The proposed a framework was developed for adopting latest Information Technology (IT) through cloud computing technologies based on SMEs business requirements in the context of Addis Ababa, Ethiopia.
4. **Demonstration**: Implementation details serve as a demonstration of the approach. The proposed framework could involve in the simulation to observe solution to the problem.
5. **Evaluation**: the evaluation we made interviews with practitioners, this will be obtained to develop further insights into the usefulness and weaknesses of this framework. Finally, thesis report.

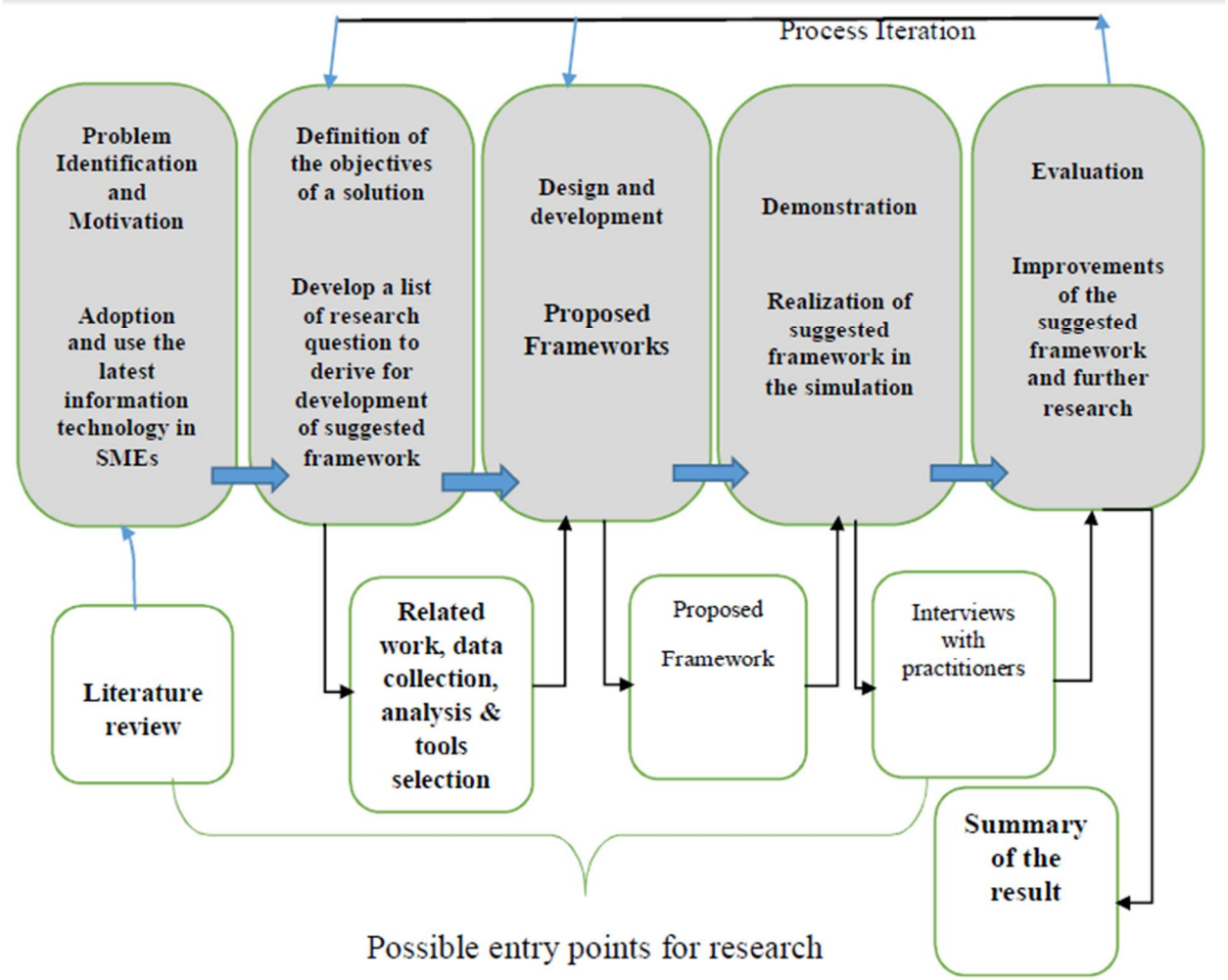

FIGURE 1: RESEARCH MODEL BASED ON DSRM PROCESS [26]

1.6.1 Literature Review

Several previously related literature (books, articles and the Internet) are reviewed in order to have detail understanding on this research works. Different techniques and tools which are relevant for the current research are analyzed, modified and used from previous works.

1.6.2 Data Collection and Analysis Method

Data Collection Method

This study consists of both primary and secondary data. The nature of the data that are required to conduct this research can only be collected through the qualitative methods. Since the

qualitative data collection is the best option for this research work to collect the required data and information in order to draw the best results. The choice of qualitative research for this research is the result of a reflection on the nature of the problem. Face-to-face interview methods were preferred to quantitative methods as they give intricate details of the qualitative phenomena. In this research, semi-structured interviews were seen as the richer and most useful option to collect data

Interviews were conducted face-to-face with SMEs managers who have used basic ICT for their business operations in Addis Ababa sub-city. This method was used to examine the current ICT utilization in SMEs that found in Addis Ababa, Ethiopia.

Data Analysis Method

The collected data was analyzed using comparative analysis. The existing cloud service and technologies reviewed from different kinds of literature and compared with the result of the collected data.

1.6.3 Tool and Technologies

There are several open source cloud-enabling platform which can provide a well-structured tool for the cloud management and complete server and storage virtualization, from such tools the researcher used OpenStack and Xen hypervisor.

OpenStack is open source software which anyone can use to build both private and public cloud [27] .The aim of OpenStack is "to produce the ubiquitous open source cloud computing platform that will meet the needs of public and private clouds regardless of size by being simple to implement and massively scalable" [28] .

Citrix XenServer 6.5 is the complete server virtualization platform from Citrix. The XenServer package contains all you need to create and manage a deployment of virtual x86 computers running on Xen, the open-source para-virtualizing hypervisor with near-native performance [29].

Benefits of using XenServer is reduced costs, reducing the number of separate disk images that need to be managed, allowing for easy integration with existing networking and storage infrastructures, allowing you to schedule zero downtime maintenance by using XenMotion to live to migrate VMs between XenServer hosts. Increasing availability of VMs by using High

Availability to configure policies that restart VMs on another XenServer host if one fails, Increasing portability of VM images, as one VM image will work on a range of deployment infrastructures [29].

1.7 Significant of the Study

This research work outlined the challenging issues faced the utilization of latest information in SMEs that found in Addis Ababa, Ethiopia. The paper proposes cloud computing framework to efficiently utilize the potential of cloud computing as latest information technology to add value for SMEs. Therefore, the significance of this study is to enable Small and Medium Enterprises (SMEs) on adoption and usage of cloud computing service. Additionally, the study could be used as a baseline for further studies of the latest information technology utilization strategy to be considered in different governmental organizations in Ethiopia.

1.8 Scope and Limitation of the Study

1.8.1 Scope

Small and Medium (SMEs) usually do not have adequate funds to acquire latest information technology but, there are a business process that performed by SMEs which can be replaced with a cloud-based service to get a cheaper and a more effective way of doing a particular on their business operations in Addis Ababa, Ethiopia. There are different types of cloud solutions available to businesses today. Hybrid clouds allow the best of both public and private cloud computing models.

Therefore, aim to deal in this study was only related to cloud services on making the adoption and usage as simple as possible by the SMEs that found in Addis Ababa, Ethiopia , so that the users can easily migrate to cloud-based services without facing any difficult issues. And this framework encourage and accelerate the adoption of cloud computing among the enterprises. The outcomes demonstrated that avoiding the capital expenditure and cost.

1.8.2 Limitation

This study's main limitation was that the information used for the results especially on the recommended framework was derived from the data obtained from the major SMEs sector who were already aware about cloud-based services, this was due to the limitation of cost and time.

1.9 Organization of the Thesis

This thesis consists of five chapters. In the following, we highlight the contributions the remaining chapters of this thesis. The organizations of the papers are as follows:-

Chapter Two: -Conceptual Discussions and Review of Related Literature

This chapter explores general, but necessary knowledge of cloud computing including the definitions and related technology. And also consists of key issues of relevant literature regarding of cloud computing adoption strategy on small and medium enterprises (SMEs) in developing countries.

Chapter Three: - Discussed and elaborated about ICT solution to Small and Medium Enterprises in Ethiopia. This section aims to determine the level of ICT utilization amongst the three categories of SMEs that have been selected for the purpose of this research.

Chapter Four: - Proposed Cloud-Based Services for Ethiopian Small and Medium Enterprise. This section presented about the proposed a framework for cloud adoption that helps to efficiently utilize the potential of cloud computing as the latest information technology solution to add value for SMEs.

Chapter Five: - Demonstration and Evaluation, and also Simulate the proposed framework and presents evaluation results, and a discussion about the results.

Chapter six: - Presents a summary of the main conclusions, limitations, and contributions of the thesis, and some proposals for the future work.

2. Chapter Two: Review of Related Literature

This chapter explores the key issues in the related literature which are relevant to this research work as standards and influenced our work such as concept and necessary background knowledge about Cloud Computing. Finally, the study is review related work of the cloud computing adoption literature on small and medium enterprises (SMEs) in developing countries.

2.1 Overview of Cloud Computing

This section presents a general overview of Cloud Computing; including its definitions, characteristics, Cloud models, Clouds architecture and advantages as well as the key technologies on which Cloud Computing rely.

Loosely speaking, Cloud Computing is a style of computing paradigm in which typically real-time scalable resources such as files, data, programs, hardware, and third party services can be accessible from a Web browser via the Internet to users. These customers pay only for the used computer resources and services by means of customized Service Level Agreement (SLA), having no knowledge of how a service provider uses an underlying computer technological infrastructure to support them. The service load in Cloud Computing is dynamically changed upon end-users' service requests [30].

2.1.1 Definition

There is no universally accepted definition. However, there has been much discussion in the industry as to what cloud computing actually means. In September 2011, the National Institute of Standards and Technology (NIST) defined cloud computing as [31]: This is a widely accepted definition of cloud computing.

> *"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction"*

The cloud is a combination of hardware and software, storage, services and interfaces that facilitate the provision of information as a service. There are many actors and participants in the

world of the cloud. The stakeholders in cloud computing include: the vendors or suppliers: providing the applications and facilitating the corresponding technology, infrastructure, platforms and information; the suppliers' partners: these create services for the cloud, offering services to clients; business leaders: assess cloud services for implementation in their organizations and companies; and end users, who use cloud services, whether for free or on payment of a fee.

2.1.2 The Characteristics of Cloud Computing

NIST argues that the cloud model has five fundamental characteristics, three service models, and four deployment models. As shown in figure 2.1.

The main characteristics are [31]:

- **On-demand self-service:** The ability for an end user to sign up and receive services without the long delays that have characterized traditional IT.
- **Broad network access:** Ability to access the service via standard platforms. (Desktop, laptop, mobile).
- **Resource pooling:** Resources are pooled across multiple customers.
- **Rapid elasticity:** Capability can scale to cope with demand peaks.
- **Measured service:** Billing is metered and delivered as a utility service.

2.1.3 Cloud Computing Models

NIST classifies cloud computing models into two main categories [31]:

- **Deployment models.** This refers to the position (location) and administration (management) of the cloud infrastructure (Public, Private, Community, Hybrid)
- **Service models.** This refers to specific services that can be accessed in a cloud computing (Software, Platform, and Infrastructure as Services).

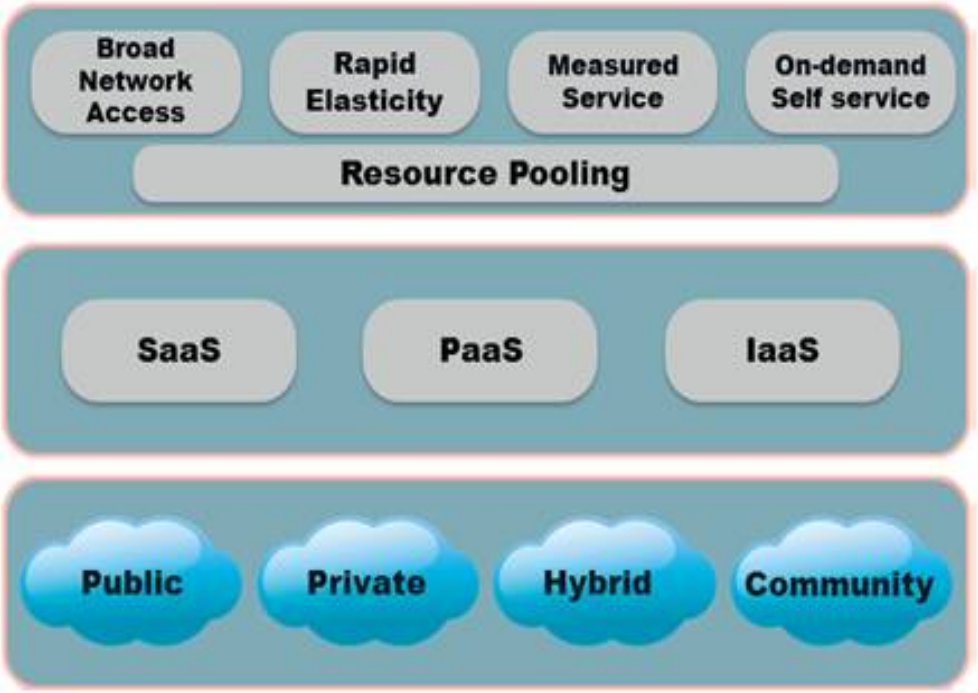

FIGURE 2: CLOUD COMPUTING MODEL [31]

2.2 Security Issues in Adopting Cloud Computing

Currently, cloud computing technology has brought the idea of storing and managing data on virtualized servers so that, applications, individuals, and organizations around the world can have the ability to connect to data and computing resources anywhere and anytime. Therefore, this means that cloud computing needs to request to the feelings of the clients and address the potential security risks in a manner that clients will feel safe and secure. By addressing security is this way clients will feel safer and secure, hence trust cloud service providers. Clients must demand transparency, avoiding vendors that refuse to provide detailed information on security programs. Therefore, an important risk factor in cloud computing in security and privacy. According to [32], data security and privacy are the two major security concerns for the organizations to adopt cloud services.

Most cloud security problems arise because of lack of control, lack of trust mechanisms etc. These problems exist mainly in third party management models and also self-managed cloud

platforms. Security is very difficult to implement in cloud computing because of the different forms of attacks in both the application side and in the hardware components.

According to [33] identification, there are seven security issues that need to be addressed before enterprises consider switching to the cloud computing model. They are as follows:

I. **Privileged user access:** Information transmitted from the client through the Internet poses a certain degree of risk, because of issues of data ownership; enterprises should spend time getting to know their providers and their regulations as much as possible before assigning some trivial applications first to test the water.

II. **Regulatory compliance:** Clients are accountable for the security of their solution, as they can choose between providers that allow being audited by third party organizations that check levels of security and providers that don't.

III. **Data location:** Depending on contracts, some clients might never know what country or what control their data is located.

IV. **Data segregation:** Encrypted information from multiple companies may be stored on the same hard disk, so a mechanism to separate data should be deployed by the provider.

V. **Recovery:** Every provider should have a disaster recovery protocol to protect user data.

VI. **Investigative support:** If a client suspect's fault activity from the provider, it may not have many legal ways pursue an investigation.

VII. **Long-term viability:** Refers to the ability to retract a contract and all data if the current provider is bought out by another firm.

2.3 Cloud Computing Reference Architectures, Models and Frameworks

This section reviewed different cloud architectures and reference framework for cloud computing.

Usually, a reference framework for cloud computing tries to offer the baseline that stands on designing some interoperable cloud services and also their integration in the existing infrastructures of the Internet and cloud service providers. On a regular basis, a reference framework should offer a draft or an architectural template that could be used by others that wish to adopt similar solutions.

A reference model consists in explaining the concepts and relationships which sustain reference architecture, while the term reference framework refers to both Reference Architecture (RA) and Reference Model (RM) [34].

2.3.1 Reference Architecture (RA)

Cloud architecture defines as a comprehensive set of capabilities that can support the delivery and management of different kinds of cloud services in a unified service management environment, and facilitate the delivery of these services in a hybrid environment [35].As shown in figure 2.4 below.

According to [34], classify Cloud reference architectures as one of two styles:

1. **Role-based:** Where activities or capabilities are mapped to roles such as cloud provider or consumer.
2. **Layer-based:** Where activities or capabilities are mapped to layers in architecture such as application or resource layers or to the service management architecture or security architecture.

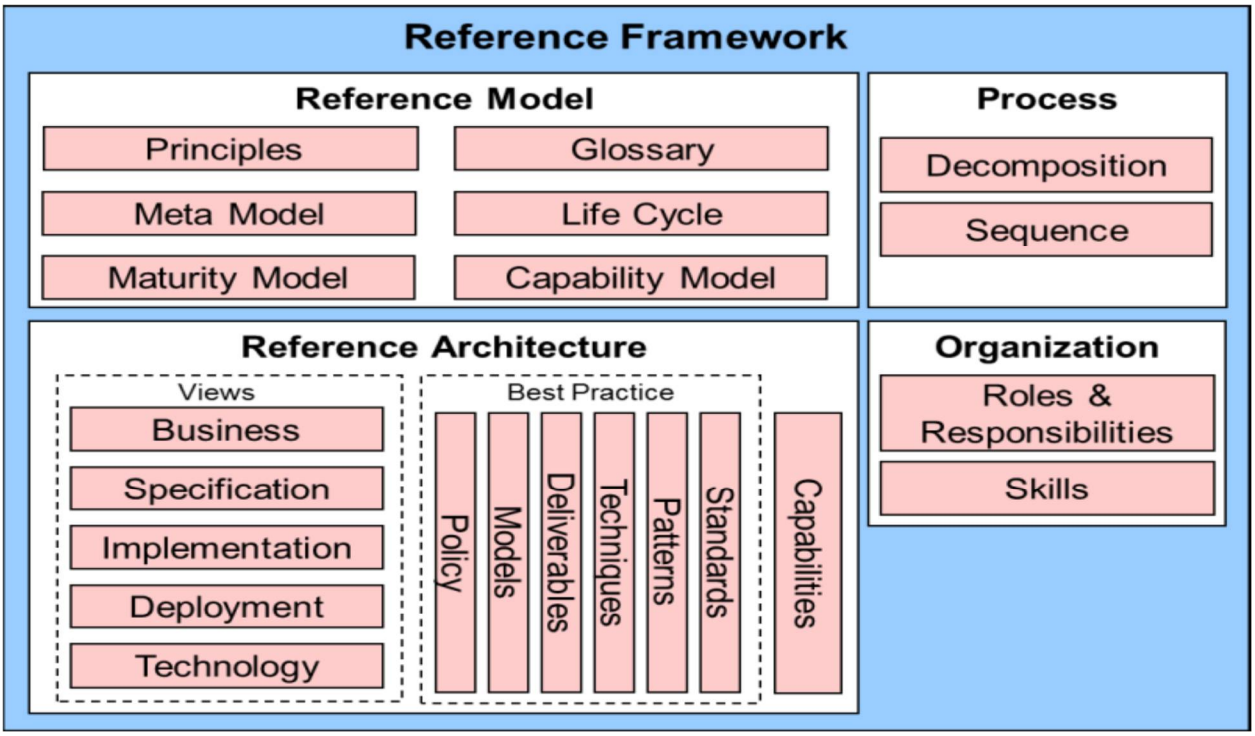

FIGURE 3: GENERALIZED REFERENCE FRAMEWORK. [34].

According to [36], the RA provides a technical blueprint for a system with a well-defined scope, the requirements it satisfies, and the architectural decisions it realizes. It ensures consistency and quality across development and delivery projects. Next, we will present four of the most important reference architectures in the field:

- Reference architecture CISCO - Cisco Cloud Reference Architecture Framework [37]
- Reference architecture IBM – IBM CCRA [38]
- Reference architecture -National Institute of Standards and Technology (NIST) [39]

Cisco Cloud Reference Architecture Framework

The CISCO reference architecture is based on the cloud definition provided by NIST. In Figure 4 shows that some of the basic elements of developing in the cloud which include the general steps of virtualization, integration, automation and finally cloud service offerings. After presenting these general steps Cisco shows the Cisco cloud strategy for Enterprises which contain 3 essential points [37]:

- It offers products, services, and solutions for enterprises to build a secure cloud
- It allows enterprises to supply secure cloud solutions and services to internal clients
- It contributes to the cloud marketplace by promoting innovative technologies, open source standards and ecosystems development.

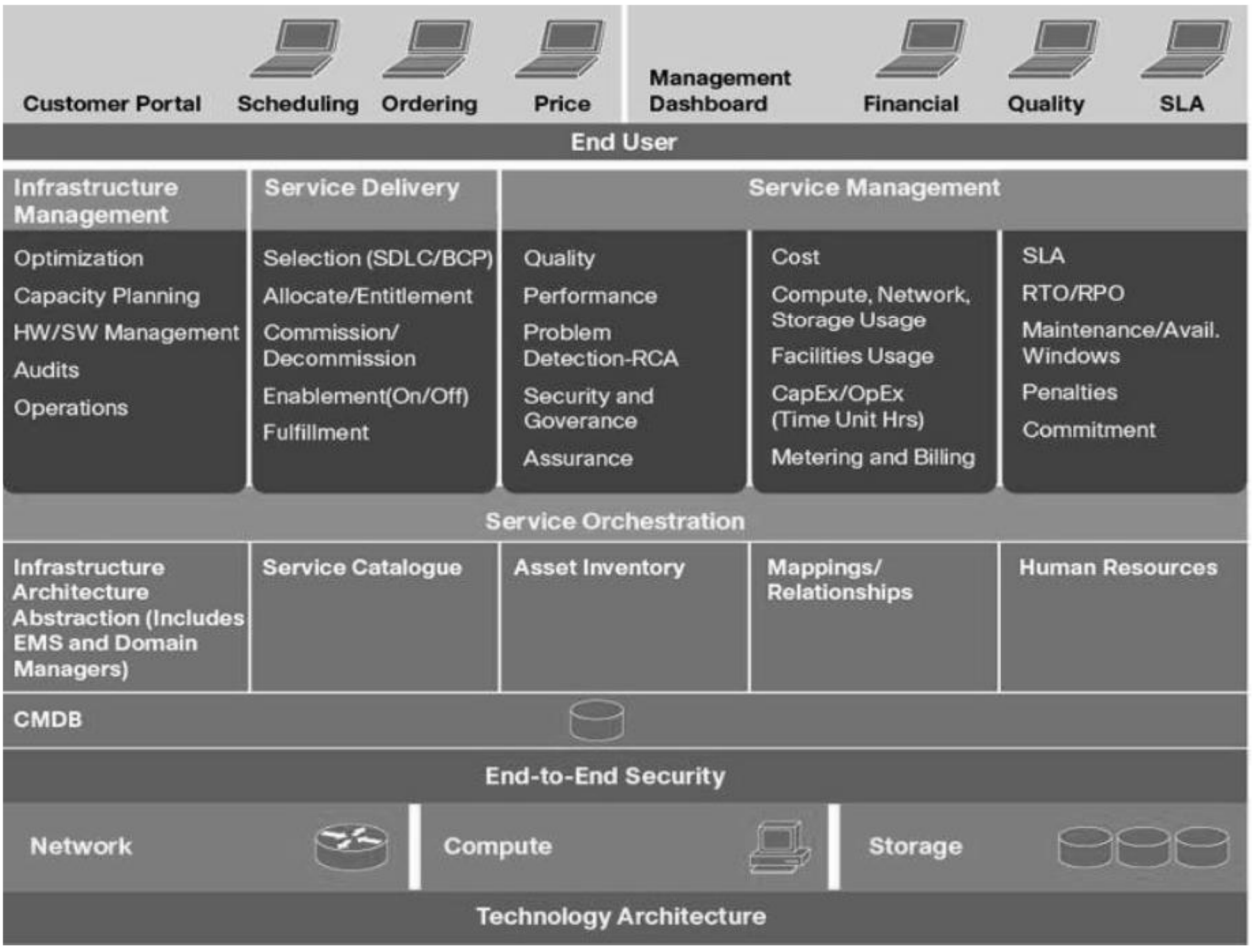

FIGURE 4: CISCO'S CLOUD COMPUTING REFERENCE ARCHITECTURE [37]

IBM Reference Architecture

The proposed reference architecture from IBM is called IBM CCRA (Cloud Computing Reference Architecture). IBM CCRA [38] is reflected in the design of IBM's cloud, developing for clients, hosting services and in IBM's products with a focus on reducing costs and obtaining a high rate of security, reliability, scalability and control.

The last version, IBM CCRA 3.0, offers a series of new benefits, these are:

- Prescriptive guidance for designing IaaS, PaaS, SaaS solutions by using IBM's products.
- Consists of various architectural products which represent the best options in IT industry in regard of designing, implementing and administration roles and permissions in the cloud for consumers, service providers and builders of cloud services.
- Represents a modular framework which allows focusing on the most important field for cloud development (IaaS, PaaS, SaaS, and CSP).

It offers a comparative sketch with the scope of realizing an analysis of the clients of the cloud with the goal of identifying integration points.

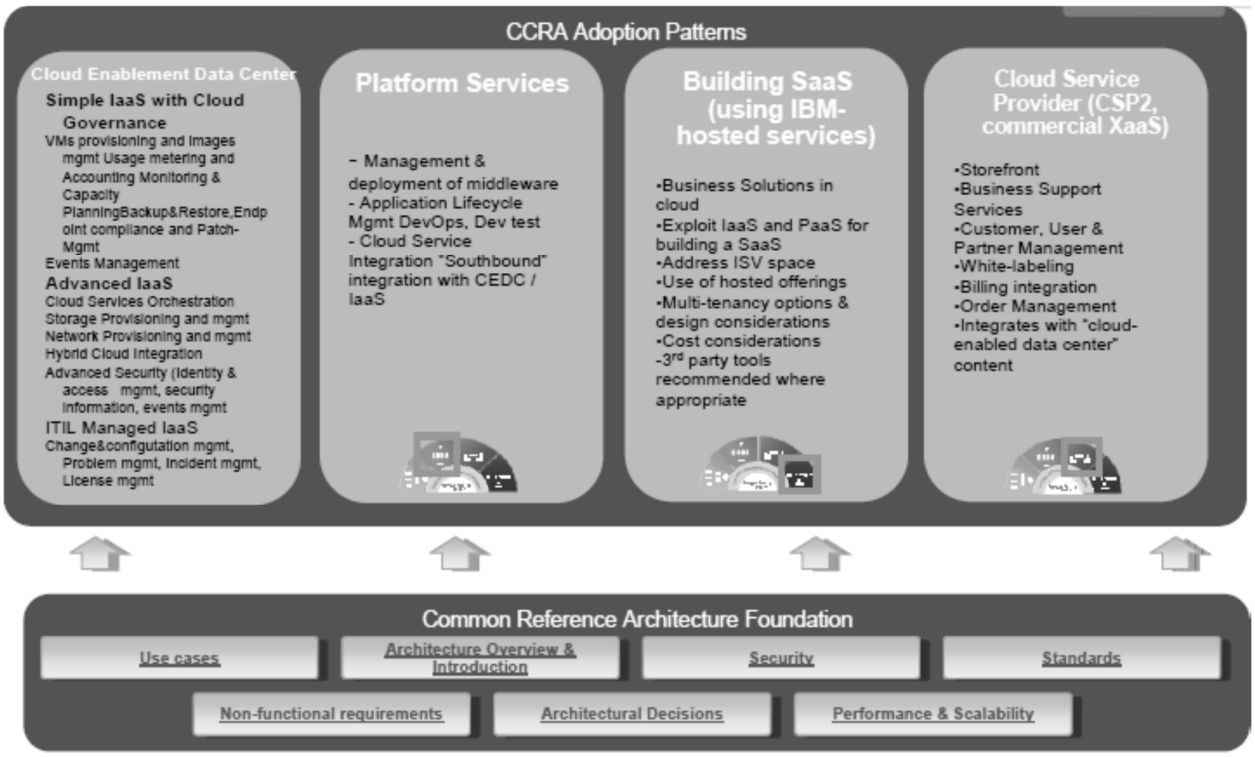

FIGURE 5: A MODEL FOR ADOPTING IBM CCRA [38]

In Figure 5 we can see the proposed model for adopting IBM CCRA 3.0, based on four models which contain:

NIST Reference Architecture

National Institute of Standards and Technology (NIST) [39], - NIST's reference architecture is a high-level conceptual generic model that represents a powerful tool when it comes to talking about requirements, structures, and operation in cloud computing.

The design of the NIST reference architecture serves the following objectives:

- ❖ Understanding and illustration of various services of the cloud in the context of a generalized conceptual model for cloud computing.
- ❖ Providing technical references to governmental agencies and to other consumers for understanding, analyzing, categorizing and comparing cloud services.
- ❖ Security communication and analysis, possible standards for interoperability and portability and reference implementations.

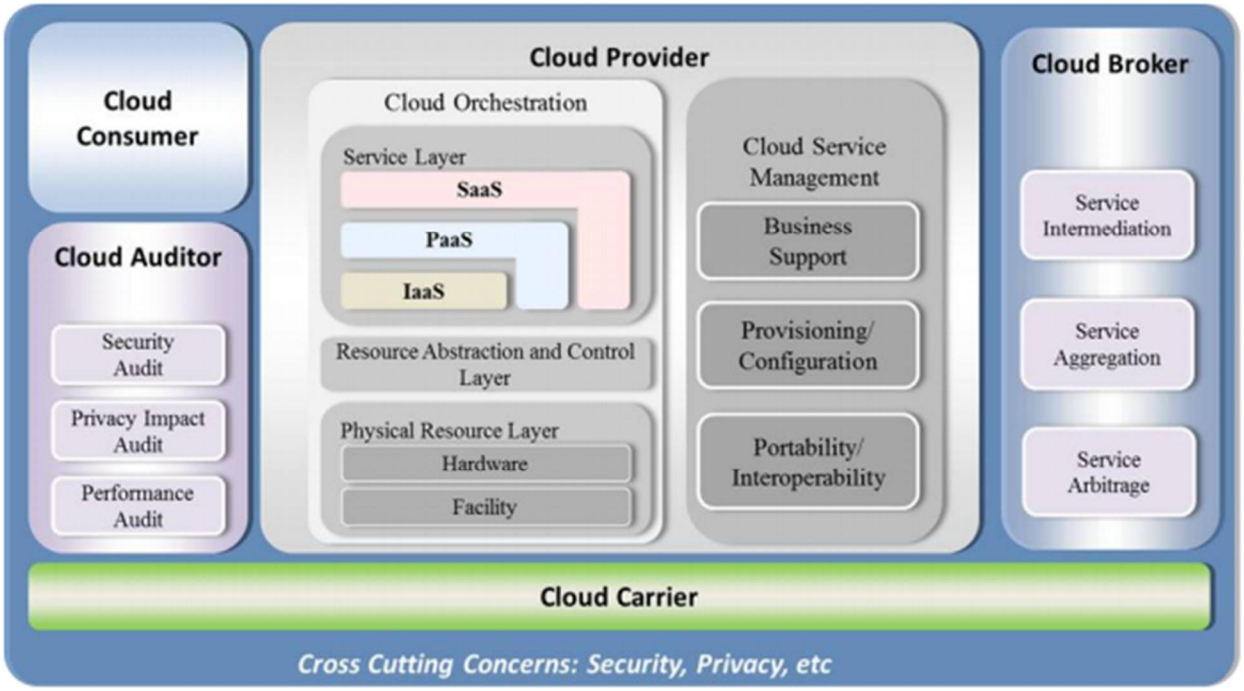

FIGURE 6: THE NIST CONCEPTUAL REFERENCE MODEL [39]

The NIST cloud computing reference architecture shown in above Figure 6, defines five major actors: cloud consumer, cloud provider, cloud carrier, cloud auditor, and cloud broker. Each actor is an entity (a person or an organization) that participates in a transaction or process and/or performs tasks in cloud computing.

- **Cloud Consumer:** A person or organization that maintains a business relationship with, and uses service from, Cloud providers.
- **Cloud Provider**: A person, organization, or entity responsible for making a service available to interested parties.
- **Cloud Auditor:** A party that can conduct an independent assessment of cloud services, information system operations, performance and security of the cloud implementation.
- **Cloud Broker:** An entity that manages the use, performance, and delivery of cloud services, and negotiates relationships between Cloud Providers and Cloud Consumers.
- **Cloud Carrier.** An intermediary that provides connectivity and transport of cloud services from Cloud Providers to Cloud Consumers.

TABLE 2. 1: COMPARISON BETWEEN CLOUD ARCHITECTURES

Model	Comparison Business level	Comparison on Architecture level	Key Difference
IBM	For general cloud computing system	Defines a layered model which considers resources, security, service, and consumer layer.	The only layered architecture
Cisco	Especially for enterprise cloud	Defines a management framework for enterprise clouds, which focuses on management of diff. components And lifecycles.	Compared to IBM, Elastra considers the only cloud Management
NIST	For general cloud computing system	Defines actors (cloud computing consumer/ provider / carrier/ auditor / broker).	Refers to the composition of system components to support the Cloud Providers activities

As a shown in the above table, the cloud architecture needs to support the basic requirements of any cloud solution, including:

- **Delivering cloud services:** where applications, data, and IT resources are rapidly provisioned and provided as a standardized offering to users over the web in a flexible pricing model.
- **Managing cloud services:** where large numbers of highly virtualized resources are managed such that, from a management perspective, they resemble a single large resource. These resources can be managed in such a way to facilitate rapid elasticity dependent on the demands for the cloud services.

Basically, the whole cloud computing system can be divided into the core stack and the management [39]. All the layers provide external service through web service or other open interfaces. In the core stack, there are three layers:

1. **Resource**

The resource layer is the infrastructure layer which is composed of physical and virtualized computing, storage and networking resources.

2. **Platform** The platform layer is the most complex part which could be divided into many sub-layers; e.g. a computing framework manages the transaction dispatching and/or task scheduling. A storage sub-layer provides unlimited storage and caching capability.

3. Application

The application server and other components support the same general application logic as before with either on-demand capability or flexible management, such that no components will be the bottleneck of the whole system

2.4 The Current Status of ICT in Ethiopia

ICT has become an integral part of Ethiopia's development programs over the last decade, following initial indifference to the development of the sector. The country faces a substantial gap between interest in the ICTs and the policy and regulatory instruments available to enable its development. ICT is one of the major components of the Sustainable Development and Poverty Reduction Program (SDPRP) of the Ethiopian government. The most consolidated and recent policy framework is the Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) that runs between 2005 and 2010. Five major initiatives were designed with regard to the ICT sector development in the PASDEP document [40].

- Promoting human resource development in the ICT field;
- Mainstreaming the use of ICT in all sectors of the economy, in the administration of government, and in the education system;
- Developing the necessary telecommunications infrastructure;
- Promoting research and development through ICT; and
- Creating enabling legal and regulatory framework.

The arrival of Information Communication Technology (ICT) as a major factor in economic growth means that more developing countries like Ethiopia will pursue policies that open up their country to mobile, the internet, and broadband penetration. The three key areas of mobile, internet and broadband will be critical to the spread of the cloud computing services. With cloud computing, economic growth can be encouraged through the cost reduction in hardware and software that businesses and governments must spend to run their information system.

The broad ICT sector policy of the Ethiopian government that derives from PASDEP was developed in 2006 by the Ethiopian ICT Development Agency (EICTDA).One of the key areas where the policy aims are "Promote the use of ICT for modernizing the civil and public service

to enhance its efficiency and effectiveness for service delivery, to promote good governance and reduce wastage of scarce resources.

To achieve the above objectives, the Ethiopian Ministry of Communication and Information Technology (MCIT) has undertaken a number of e-Government initiatives to improve the internal efficiencies within the government organizations and to improve the access to government services for the general public. These initiatives are explained as follows [40].

The major initiatives can be divided into four major categories: - Infrastructure, the backbone of ICT activities, connectivity, and networking.

Infrastructure

Ethiopia has been building its fiber backbone. A national backbone fanning out from the capital Addis Ababa in seven directions has been under construction as a result of a massive investment through a vendor financing loan agreement with China's Zhongxing Telecom Corporation (ZTE).The 10,000km fiber network connects 78 towns with a capacity of STM-1 (i.e.155 Mb/s), 46 towns with a capacity of 2.5 GB/s and 9 towns with a capacity of 10 GB/s. In addition, National Data Center, Regional Data Center, WoredaNet, School Net, Ethernet, AgriNet are among major e-government projects that are upgraded following the construction of the National backbone [1].The Status on ICT Infrastructure in Ethiopia as indicated as below table.

TABLE 2.2: STATUS ON ICT INFRASTRUCTURE IN ETHIOPIA. **[1]**.

Services	Number of Users	Capacity in Five Years	User per 100 Inhabitants
Landline Telephone	1 Million	8.5 Million	10
Mobile	10 Million	40 Million	50
Internet Users	200,000	7.17 Million	8.5
Ruler Connectivity (In 5KM Radius in %)	49.3%	90%	-
Wireless Coverage of the Country	<50%	90%	-
International Link Gbps	3.2	20	-

2.5 Review of Related Work

This section describes the available literature on best practices of cloud-based service implementations and framework development works for cloud-based service adoption strategy in the small and medium enterprise.

2.5.1 Need for Cloud Computing for SMEs

According to [41], as compared to large business industries, the access of SMEs towards human and financial resources is low. Therefore, they do not have the ability to effectively use and upgrade their IT systems in order to meet changing business requirements effectively. Cloud computing offers an appropriate solution to these IT issues by providing scalable capabilities and infrastructure to SMEs. Therefore, SMEs which are operating with small IT departments can rent IT services rather than buy them by utilizing their limited resources. They have also identified some other benefits of cloud services, for instance, efficient use of the computing system, low level of hardware investment, and faster upgrades of software.

Moreover, the literature shows that cloud computing adoption by SMEs indicates that the enterprises are motivated to use cloud computing services through the internet in order to enhance their business capabilities. The changing nature of cloud computing makes it highly suitable for small-medium enterprises and also proposed two business models for companies which are willing to adopt cloud computing services – business models for companies with existing IT infrastructure and business models for startup companies [42]. Cloud computing provide a diversity of needs of computing resource for users and organizations. For many organizations, the advantages to adopting cloud computing are increasingly attractive as it can add capacities quickly to an IT system without investing in new expensive infrastructure, buying new software, or training new personnel [43]**.**

One of the attractive and important cost issues in the cloud computing is the capability to pay for service based on needs and avoiding the large expenses for computer systems buys [44]**.**

2.5.2 The Existing Cloud Adoption Frameworks

Cloud Computing is helping enterprises to address issues of cost, efficiency, flexibility, and scalability among others. From the search on Google scholar, there are three articles selected that aim to guide and assist the decision makers in selecting and implementing a cloud solution. All of these articles are published after 2010, indicating that the topics surrounding the cloud strategy are still relatively an infant compared to the implementation strategies of other IT systems. These areas have been fairly covered within previous literature review.

A goal-oriented requirements engineering approach for cloud adoption by [45]. The objective of this approach is to help the users in screening, matching, and negotiating their requirements towards the cloud service's provision and also to manage the tradeoffs concerning the matches and mismatches of the requirements. The processes of this requirement engineering for cloud can be seen in Figure 2.2 and are described as the followings.

1. Acquire and specify goals. The goal is defined as a target that must be achieved by the system.

There are three categorizations for goal definition: 1) the strategic goals – concerned with the survival of business, 2) high level or core goals – are the main motivations to adopt a cloud solution, and 3) operational goals – are the more specific requirements such as the password protection, encryption mechanism, etc. These goals will then be prioritized by the key stakeholders.

2. Assess the features of cloud service provider. This is when the search for potential cloud providers is started. Several considerations in this phase are the total cost ownership against the budget, the cloud provider's reputation, and whether the cloud solution satisfies the expected goals.

3. Perform matching. The matching process involves the information gathering and analysis to examine whether the cloud services meet the goals. The cloud service can be considered as satisfactory if the satisfied goals are within the acceptable range.

4. Analyze mismatches and manage risks. The mismatch between goals and cloud services is carefully analyzed to explore the tradeoffs and manage the risks. A risk management is necessary to help in identifying and handling the risks prior to their conversion to threats.

5. Cloud service provider selection. The most appropriate provider is selected based on the analysis of value, cost, and risks.

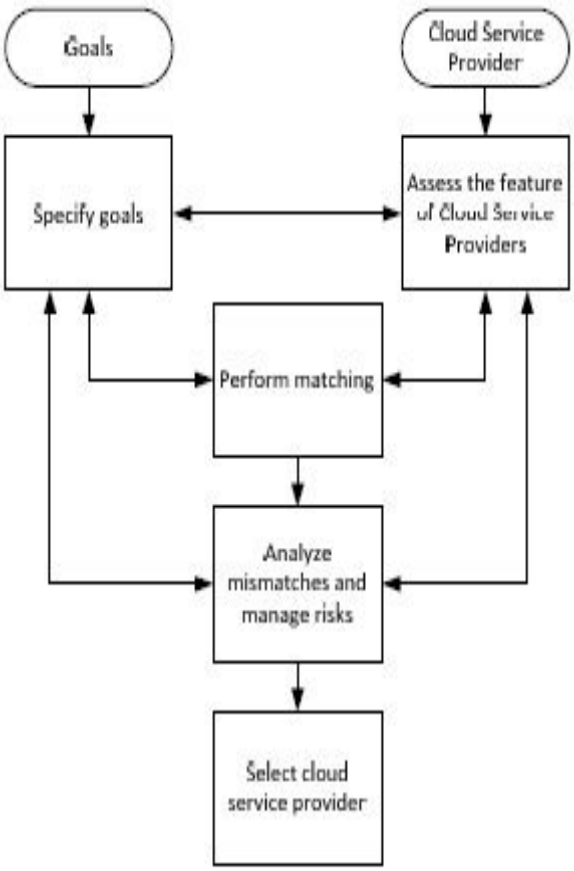

FIGURE 7: CLOUD ADOPTION APPROACH BY ZARDANI AND BAHSOON [45]

Cloud adoption toolkit by [46] . A conceptual framework for organizing the decision-making including the supporting tools to do the analysis is elaborated. There are five main steps within this framework, as shown in Figure 2.3.

1. **Technology suitability analysis**. This phase is to ensure that the technical fit of cloud services support the desired technological characteristics. A simple checklist is defined for this analysis and consists of the following characteristics: the desired elasticity, communications, processing, accessibility, availability, security requirements, data confidentiality, and regulatory requirements.

2. **Cost modeling and energy consumption analysis**. This phase supports the decision making with the accurate estimation of the costs and energy consumption associated with the use of cloud computing. The output of this phase could also support the system architects in designing the appropriate IT infrastructure in term of the operational costs and energy consumption.

3. **Stakeholder impact analysis**. This is to assess the organizational fit whether the impacted organization can cope with the potential impacts caused by the cloud services in term of practicalities (time, resources, capabilities), social factors (values, satisfaction, status), and political factors (fairness of benefit distribution, risks, etc.).

4. **Responsibility modeling**. This is about the assessment of operational feasibilities by creating a set of responsibilities and mapping them with the activities to realize the nonfunctional characteristics of the system. This is also to identify and determine the strategic dependencies between organizations.

5. **Requirements and implementation.** This is when the actual implementation takes place.

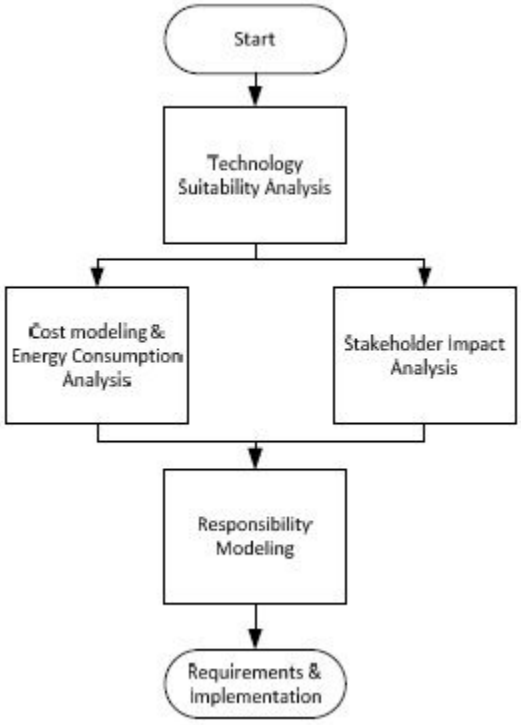

FIGURE 8: CLOUD ADOPTION TOOLKIT BY KHAJEH-HOSSEINI [46]

Cloud adoption strategy by [47] . This strategy comprises six phases of adoption lifecycle, starting from the initial phase until the governance of continuous operations.

1. **Initial planning**. In this phase, a high-level analysis exploring the business objectives and how adopting a cloud can fit with the business strategy is executed. There are several key outputs from this phase, i.e. the business model in which the current capabilities and values are explored to find the necessary improvements, a high-level plan of projects including the project owners, and the expected business outcomes to be realized in a due time.

2. **Enterprise capabilities and cloud vision**. The focus of this phase is to provide an understanding of the overarching abilities needed to support the cloud implementation.

Several key work artifacts from this phase are the vision statement of cloud adoption; adoption pattern; a business case which provides information about plausible costs and benefits, value propositions and ROI for the cloud; and a governance model.

3. **Target architecture and cloud enablers**. In this phase, the requirements influencing the cloud adoption decisions are explored in greater details. There are three areas relevant for the updates in the existing EA in relation to the cloud adoption: 1) the business architecture, 2) the information system, and 3) technology and infrastructure architecture.

4. **Gap analysis and transition planning**. Gap analysis is necessary to help the comparison of company's actual performance with its potentials and thus to know the shortfalls of the current situation. A transition plan is a preparation for a change and for this, a sufficient understanding of the change management needs is essential to achieving the benefits. The key deliverables for this phase are a change management plan which addresses how to organize the people and the organization from its current state to the future state, and a cloud adoption roadmap which provides a list of actions for realizing the cloud adoption strategy.

5. **Implementation planning**. This is the final phase of cloud adoption strategy in which an arrangement with the cloud provider is made and the contract is signed to commence the necessary works. The key activities of this phase are the SLA arrangement and the formulation of the integration requirements.

6. **Governance**. This is a continuous activity which underlines the whole processes of cloud adoption. The governance is expected to provide a strategic direction which defines how the cloud adoption will be performed, managed and controlled.

2.6 Conceptual Framework

This section is provided and facilitates knowledge accumulation and creation about the framework for cloud computing adoption for SMEs. Its purpose is to develop the conceptual framework and related hypothesis based on the previous literature. This study will propose a framework of cloud computing adoption strategy by developing a theoretical framework.

2.6.1 Adoption of Cloud Services and its Challenges

Cloud adoption is a strategic move by organizations of reducing cost, mitigating risk and achieving scalability of IT resources capabilities. Cloud adoption may be up to various degrees in an organization, depending on the depth of adoption. For instance, a survey conducted by [48] revealed that organizational perceived benefits such as accessibility, scalability, cost effectiveness, and security can influence the decision on cloud computing adoption. [42] Found that the capacity of IT resource, resources usage, data privacy, and the scope of business activity could also affect the adoption of cloud computing in firms.

The researchers are investigating adoption challenges in clouds, such as Service Level Agreements (SLA) [49] , business models and classification [50]. SLA focuses on billing models and has direct implications on prices. Business models and classifications tend to focus on the way organizations can obtain the profitability not limited to SLA. A limitation about SLA is they only focus on operational levels and are not directly connected to strategic levels. Other aspects of successful cloud delivery have to be investigated at a wider scale, particularly the alignment between the strategic and operational focus of cloud adoption.

To help organizations designing, deploying and supporting clouds, especially private clouds, considering both strategic and operational approaches for cloud adoption is recommended. [44] Describe cloud computing technical adoption challenges and considered vendors' lock-in, data privacy, security and interoperability as the most important challenges. [51] Identify human-social issues in cloud adoption to be resolved and explain their importance using case studies. This means adoption challenges need to take technical, financial and organizational issues into strategic consideration before adoption and implementation take place.

2.6.2 Influential Factors of Cloud Computing Adoption Theories

The purpose of this section is to review related literature for identify the most frequent and used variables that are related to the adoption of cloud computing services by SMEs. Prior literature has investigated a number of influential factors in the adoption of cloud computing that can be categorized into three types, the technological factors, organizational factors, and environment factors.

The following are researchers that focus on cloud computing adoption using different adoption theories.

[52] Employed technology acceptance model (TAM) to find the factor that affects the adoption of consumers to cloud computing. Findings of the quantitative study showed that perceived usefulness, perceived ease of use, organization type, and security has a strong association with the adoption of cloud computing.

According to [53] TOE framework consider technological, organizational, and environmental factors with related sub-factors in developing an SME cloud computing adoption model that is theoretically grounded on the technology– organization–environment framework and found that these three factors influence the adoption of cloud computing. [54] Used similar approach and employed TOE to find the factor of the cloud. The findings showed that innovation characteristic has a strong influence on cloud computing adoption. Similarly, technology context .and organizational and environmental context have a strong influence on the adoption of cloud computing.

[55] Merged between TOE and TAM to examine the factors that affect the cloud computing adoption. The findings showed that relative advantage, compatibility, complexity, organizational competency, training and education, top management support, usefulness, and ease of use are the factors that affect the adoption of cloud computing. [56] Assessed the factors influencing to small & medium sized enterprises (SMEs) to adopt cloud computing in developing economies. The study revealed that key factors like reduced cost for IT purchases and maintenance, improved communication internally and externally, scalability, business continuity and access to expertise are the key drivers for adoption and main barriers were lack of skill and knowledge, poor internet connectivity, security and data privacy, lack of trust and difficulty in integrating

with in-house systems. Additionally, it was found that top management support, resistance to new technology, the presence of existing infrastructure and compatibility with cloud services, the competence of cloud provider and vendor support are the most influential organizational factors used in the adoption decisions.

Moreover, these theories also are briefly mentioned under the table below.

Table 2.3.OTHER OF CLOUD ADOPTION STUDIES

No.	Author	Objective	Methodology	Key Findings (factors)
1	Abdollahzadehgan, *et al.*,2009 [57]	Evaluating organizational success factors for adopting cloud computing in SMEs.	Qualitative methodology was used to gather data and evaluate it under the TOE framework	Organizational factors ▪ Top management support ▪ Firm size ▪ Technical readiness
2	Morgan, Lorraine [58]	Exploring factors that affect adoption of cloud computing technologies	The qualitative interview was used to collect data and analyzed using open coding and axial coding under the TOE framework.	*Technological* Liability, relative advantage, compatibility, complexity *Organizational d*esire to improve collaboration and promote openness, increased traceability and audibility, losing control of IT environment *Environmental* Security and legal issues,
4	Seo, Kwang-Kyu [59]	Exploring Factors in IaaS cloud service adoption	Uses TAM framework	perceived security

In summary, we conclude that the above-mentioned cloud computing adoption models are twofold:

1. Although various factors affect cloud computing adoption among prior researchers' findings, all these factors can be classified in technological, organizational, or

environmental contexts. Thus, it is feasible to apply the technology-organization-environment (TOE) framework to explore the cloud computing adoption issue.

2. Most studies have explored the importance of the technological factors affecting cloud computing adoption. However, the influences of environmental and organizational factors on cloud computing adoption vary across different industry contexts. Therefore, there is a need to analyze the determinants of cloud computing adoption in the different enterprise to acquire a better understanding of cloud computing adoption.

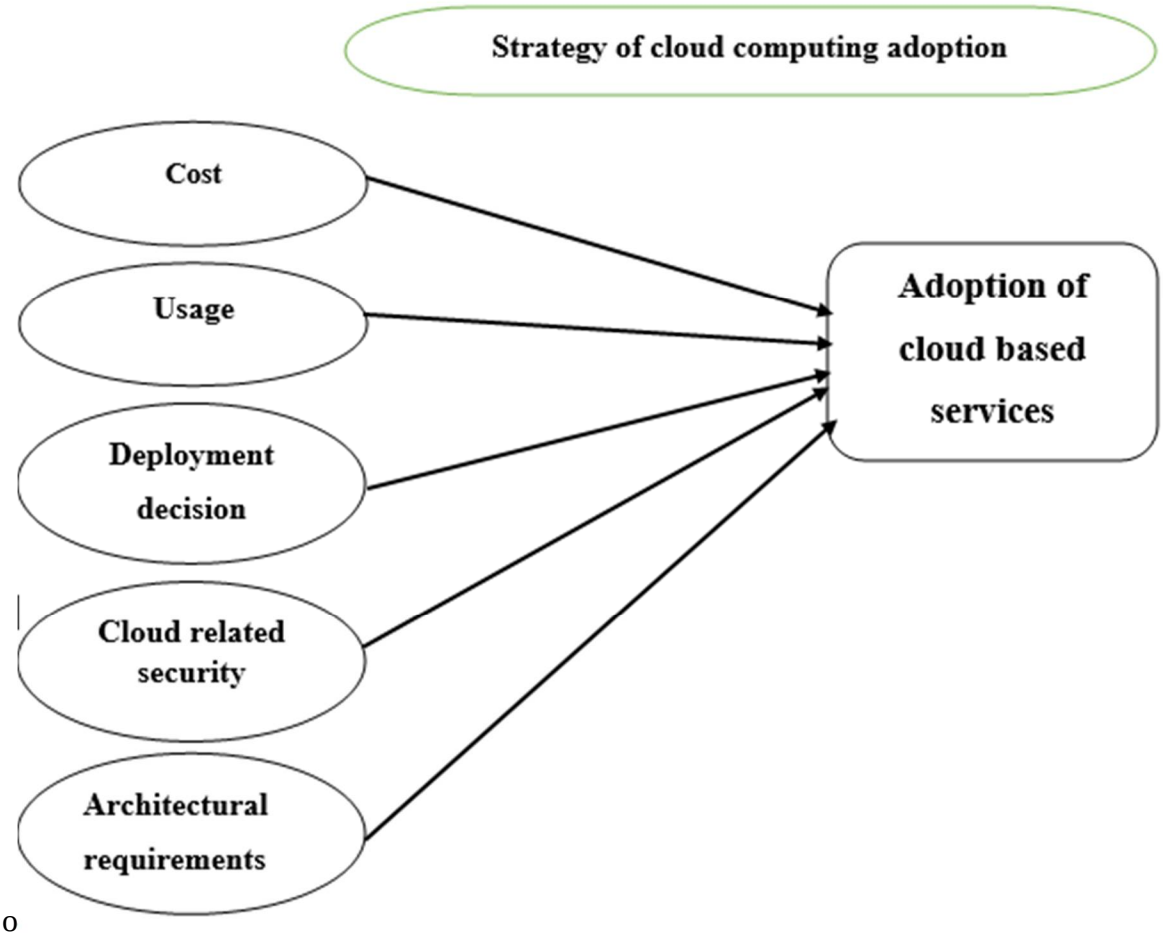

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FIGURE 9: SHOWS THE RESULT CONCEPTUAL FRAMEWORK

Figure 9 shows the resulting conceptual framework that was used to carry out the baseline study on cloud computing for SMEs. The direction of arrows shows an element of causal effect. As shown in the figure above the conceptual framework for this study consist of different elements.

3. Chapter Three: ICT and Small and Medium Enterprises in Ethiopia

3.1 Introduction

The role of ICT ranges from changing individual lives to controlling the step and path of the world economy. One of the reasons for this limitless coverage is the availability of ICT for almost every business and social activity. ICTs and ICT based services can be produced to serve a general purpose that crosses industries and business activities. On the other hand customized ICTs and its' services are what really make ICT the essence of every business organization. Successful IT program implementations among other things need holistic perspective, understanding of dynamic forces at play, the ability to project future consequences of actions taken today and managing the right alterations to get the desired results.

3.2 Overview of Research Methods

In order to develop the knowledge base about the current state of IT need, structure and usage in Ethiopian SMEs, the study followed qualitative research approach. This method was selected because of one of the study aims was to explore about ICT utilization and challenge in SMEs, the current ICT infrastructure and service delivery strategy and finding an alternative solution from an operational point of view.

The population of this study does not include all SMEs in Ethiopia due to limitation of resources such as time and money. The interviewed companies were selected from research site for the following reasons: Addis Ababa is the capital city of Ethiopia; also largest city in Ethiopia, Moreover Addis Ababa is considered the commercial and industrial center in Ethiopia. The total number of MSE in Addis Ababa are 1027 (Micro and small enterprises development sector annual statistical bulletin (2010/11-2014 Fiscal Year).

In the qualitative research stage, purposeful sampling focuses on selecting information-rich cases. It typically focuses in-depth on relatively small samples, even single cases, which have been purposefully selected. The samples for the present study are selected from Addis Ababa which include both SMEs that have successfully employed an IT system for their business

operations and those that have faced problems. The main reason for selecting these companies rather than the researcher's observation are enterprises with 6 to a maximum of 100 employees. Another criterion when the enterprises were selected was that they should basic ICT adopt at least one of the following areas of ICT: office packages (Word, Excel etc.), Internet searching and browsing, e-mail, or a Web site for their business activities.

The researcher used the following sample size determination formula developed at University Park by Watson (2001).

$$n = \frac{\left(\frac{P[1-P]}{\frac{A^2}{Z^2} + \frac{P[1-P]}{N}}\right)}{R}$$

(Watson, 2001)

Where:

n: minimum sample size required-30

N: total number of people on the population-1027

P: estimated variance in population - 50%

A: precision desired – 23.18%

Z: Based on confidence level – 95%

R: Estimated response rate- 98%

Purposive sampling was used for data collection in this study, which means that the organizations are selected purposive form, because of according to the observation the number of organizations that aware about cloud based serves were small. So that the best suitable respondents were chosen, these were manufacturing, service and retailer enterprises from different SMEs that found Addis Ababa, Ethiopia. The number of SMEs was obtained from the Addis Ababa City Administration Micro and Small Enterprises Bureau that covers all of the ten Sub Cities. The selected enterprises have better balanced distribution of main types of SMEs that are given higher priority. Therefore, the main reason to select these enterprises are the nature of the representativeness of their data.

Finally, after the collected data are analyzed and summarized for a better understanding of the IT utilization and usage. The procedure followed in this study was: using the interview to collect data, describing the data and analyzed, it compared to relevant literature review then findings of the study.

3.3 Usage of IT by SMEs in Ethiopia

In developed countries, ICT adoption to SMEs has changed the way businesses are conducted in order to have a strategic advantage in their various operations. This section shows the empirical data of the study and presented data, in such a way that the description of each enterprise are categorized and will be followed by its position in view of the three issues shows as the major aim of this study correspondingly as:

- Traditional IT helps for Ethiopian SMEs in current situation of their business operation
- Current ICT service delivery strategy efficient for SMEs in Ethiopia.
- SMEs can choose the most suitable option for any specific application or service to gain benefits into latest information technology particularly cloud computing.

The list of the interviews questions is found as an appendix A on this thesis.

3.3.1 Firms Taking Part in the Study

This section aims to determine the level of ICT utilization amongst the three categories of SMEs that have been selected for the purpose of the framework. A measure of the level of ICT utilization simply means to identify the different types of ICT applications and facilities that are in used in these SMEs. A wide range of ICT solutions/systems ranging from basic to sophisticated were identified as applications mainly used or utilized in the SMEs, and these are highlighted below.

Category One: Services

In these categories, most of the enterprises use computers for everyday activities mainly in the accounts section and for secretarial services. The major software besides basic office applications used in the company is the Peachtree complete accounting software which is used offline.

Under this category, most of them have not a web page yet but plans are there to have one that would also enable at least to receive orders online. The interviewee believes that the understandings of internet-based IT solution are growing very fast in Ethiopia in recent years. The remaining step, according to them, is building the infrastructure capacity and introduction of

a better service that allows adoption of online systems. Finally, all of them have a little perception about cloud computing technology.

According to the interviewee suggestions, businesses in Ethiopia are not catching up with the rest of the world since there are limitations of infrastructure and the services required to utilize the opportunities that could be grasped by utilizing the internet technologies. The solution to these, the government has to build and introduce recent internet technologies and its police.

Category Two: Retailer

In these categories, most of the enterprises have its own custom made application software that is used to track inventory of items, record sales, produce several types of receipts as required and generate reports and maintain the database. The accounts section uses the records generated by the system to process the finances using Peachtree accounting software but not directly connected to the custom made an application. Some marketing manager says, "We appreciate our company's utilization of the accounting software because it has enabled us to have a good performance in inventory and accounting records. This shows that we have the potential to adopt more new IT systems."

Some of the enterprises have a website of its own where it introduces the services given and uses it as a gateway to the global market. Identifying suppliers and communicating with suppliers are done through the internet and email. According to the most interviewees, says, "The enterprise uses online resources to locate suppliers in order to identify items with good quality and price suitable for the country's market."

Most of the manager hopes for an integrated system that would allow several functions to be combined to result in an efficient performance. Since the most enterprise is involved in the retail of computer related goods, it's not significantly affected by the cultural constraints as would other businesses that deal with none computer related items. The interviewees explains this as follows; "Cultural and financial issues are not much of concern but rather the main reason for the company for not adopting an integrated system between financial and sales records as well as communicating among its branches is mainly lack of technical expertise in the market with adequate experience in this area.”. According to the interviewee, one of the expected constraints

is getting the customers to exploit the online system because it has been done through other traditional means before.

According to interviewees ‘suggestion, "We expect to get a much more efficient workflow and profitability by using the new system because getting orders would become so easy and that enables us to get into the new era of utilizing information technology for business growth. “The interviewee also points out that the technical capability to run and maintain the system might be another challenge to face when implementing the system. And IT graduate has already been hired to work on running the system and the software developing firm that took the project has promised to work with the company in giving training and provide after-sale maintenance services. Interviewee continues to say, "...after the system is implemented and starts to work well, we will try to adopt or integrate other systems such as the accounting software to make our work even more efficient."

The owner believes that there are many opportunities for businesses in Ethiopia in adopting information technology into the day-to-day workflow given that not much has been exploited in this area. According to the interviewee, many new businesses are emerging into the market and this makes the need for adopting such latest internet technology even more timely and necessary. Interviewee conveys their view on the prospects by saying, "The financial, technical, and service readiness are growing from businesses and therefore it is inevitable that many such technologies should be adopted in the coming years. However, we need to adopt e-commerce in the market and train our staff as well as hire skilled ICT personnel on parallel to the needs of businesses as well as customers who want to do transactions online."

Category Three: Manufacturing

In these categories most of the enterprises, computers are available in the most office mainly used for secretarial purposes and the other system used in such enterprises is the accounting software, Peachtree, and QuickBooks and Some of the enterprise use Microsoft Access is used for keeping database both used offline. Email is used for communications and a web page is used only for advertisement purposes at present but a few enterprises are already in the process to get a new system that enables customers to place orders online.

Communications are made through emails with customers and potential suppliers for import and potential markets for export are constantly researched on the internet by the marketing personnel. Most enterprise has a website on which it maintains updated information on the items for its current and potential customers, but not regularly.

Some the interviewee puts the plans in improving the functions of the website by saying, "We are now at the final stages to implement our new more dynamic online system that enables our partners to put orders and get detailed records about the transactions between the two parties by allowing them to have their own accounts on which they could trace data such as the types, volume, and value of items under transaction; reports on the status or progress of goods in transit and so forth."

Most interviewers put their expectations from the online system by saying, "The benefits of this system would be valuable for us and our partners in improving performance by facilitating communications to be prompt and accurate. This would accelerate our transactions and produce more sales turn over the amount and more profits. It would also help us to grow into a more global and advanced competitor in the market. “According to the interviewers, one of the reasons for the company not to employ a more dynamic online system earlier is the unavailability of experienced professionals in system development affordable by small businesses in the market.

They gave the remark on the current and potential situations saying, "Businesses in the country can benefit from ICT and the internet if we involve ourselves in the global advancement by adopting useful systems like the online system and safe transfer of payments. The government should also strive to provide the necessary ground in the infrastructure required as well as policies and regulations for such services to facilitate the growth of businesses in the country since the current monetary policy on transfer of funds is tight."

3.4 Data Analysis and Results

3.4.1 Data Analysis

This study was intended across three categories of economy sectors such as manufacture, service, and retailer. These economic sectors are the most important aspects to examine the current ICT usage and practice. Analysis of requirements through comparative analysis approach of information obtaining from primary data with relevant literature finding for presenting the

requirements to constructing the cloud computing framework that intended in this study. In the literature reviewed in this study, there were concepts of cloud computing adoption. Accordingly, interview and related literature review are employed for this study to develop the knowledge that is required for proposed framework for cloud computing adoption.

In this part of the data analysis, reports about the levels and purposes of ICT utilization within the selected SMEs were described and presentations in the table.

TABLE 3.1 SIZE OF THE ENTERPRISE INVOLVED IN THIS RESEARCH

Size of the Enterprise	Frequency	Percent
Small	10	33.3
Medium	20	66.6
Total	30	100

As we see from Table 3.1: the research is concerned 10 (33.3%) of them are small enterprises and 20 (66.6%) are medium enterprises. This is categorized by their employee numbers.

TABLE 3.2 TYPE OF ENTERPRISE OR ECONOMIC SECTOR INVOLVED IN THIS RESEARCH

Enterprise or Economy sectors	Frequency	Percent
Manufacture	10	33.3
Service	12	40
Retailer	8	28.8
Total	30	100

Table 3.2: shows that the type of enterprise or economic sector involved in this research is Manufacturing 10 (33.3 %), Services 12 (40 %) and Retailer 8 (28.8 %).

TABLE 3.3 ICT USAGE UNDER THE SELECTED CATEGORY

		Frequency	**Percent**
If you are an ICT user for what purpose you use it?	Eight of them have websites	8	26.6
	Three has a database	3	10
	Ten use accounting software	10	33.3
Do you have challenges when you use ICT for your business?	High cost of ICT infrastructure	30	100
	Lack of qualified staff		
	High cost of software applications		
Do you think the current ICT services and supports that are provided are enough to achieve your business goal?	Strongly disagree	3	10
	Disagree	15	50
	Agree	8	26.6
	Strongly agree	5	16

Table 3.3 of the research has shown that from the total (30) the respondents 8 (26.6 %) have websites, 10 (33.3%), are used accounting software while minor respondents 3 (10 %) are used the database. Moreover, the study reviled that all of the respondents which is 30 (100%) of the respondents answered that high cost of ICT infrastructure, lack of qualified staff, the high cost of software applications. This table also has shown that a large number of respondents 15 (50 %) of the respondents disagreed that Information Communication Technology services and supports do not provide enough to achieve your business goal of small and medium enterprises, while 3 (10 %) of them are undecided. Moreover, the study has confirmed that some of respondents 8 (26.6 %) of the respondents disagreed that ICT does not help in attaining SMEs satisfaction in business operation.

The reality of small and medium enterprise in Addis Ababa, Ethiopia according to the above presented on the study, they have not been able to utilize the online system as expected and its consequential fewer benefits on a significant level. Their best achievement from ICT thus far is having static web pages and some with a little more features like accounting software and database of products, suppliers or clients. Most of these firms are only on planning stages to adopt some primary level online system and haven't invested in it yet.

Almost all of the respondents have agreed that there is a lack of reliable and cost-effective infrastructure to implement the accurate Internet-based IT systems in line with the dominant circumstances to the country as well as the specific company.

Our respondents have also pointed out that not enough infrastructures have a negative impact on the limited existence of ICT usage in the country. They add, this is mainly due to the monopolistic and very expensive provision of Internet services by the government-owned EthioTelecom.

3.4.2 Results

In this part, a brief comparative analysis was performed in order to determine of the frameworks suit meets the research objectives. One of the main criteria used in this comparison is the alignment of existing cloud service and technologies with the result of interviewed data. The result gave us a new perspective, how cloud computing was seen from the business world. The problem is often that cloud computing were not get the proper chance in competition with traditional IT solution because of the lack of skill. We found under the research that some companies were hesitant to move into the Internet-based IT solutions; therefore the result from this study was given to find information about the low knowledge of cloud services. The collected data have in less fulfilled the expectation to adopt SMEs to cloud services.

This study indicated that the Ethiopian SMEs have low knowledge to adopt this new technology. There is need to educate the market and show the business organization the potential offered by this technology. So far most of the organizations do not know why they should ignore this technology prior to other available technologies, but cloud computing have various advantages over other existing technologies.

The technology of cloud services mainly consists of many components that include a cluster of computing, centralization of data, broadband network, and grid computing. This component is being used widely and especially in different industry and company. Cost saving is one of the key advantages of the cloud computing services. The saving is not only in money but also in time and effort needed to operate the system and conduct the business. Therefore, this study has developed cloud architecture to provide adoption cloud services. While the data that was gathered through this study may not be sufficient to be generalized as a framework, it is enough

to identify the prominent challenges and give insights about the current state (in cultural and legal aspects) and role for adopting cloud computing in SME sectors in Ethiopia. With a minimum infrastructure cost and resource consumption to migrate to the cloud

3.5 Summary

The summary of this section address ICT that used to improve the activity that made by SMEs at every step of their business process. Even without Internet connectivity, SMEs can use PCs for basic word processing, accounting, database and other business operations. Appropriate ICT can help SMEs cut costs by improving their internal processes, improving their product through faster communication with their customers, and better promoting and distributing their products through cloud computing.

Users have a reason for adopting cloud computing into their business. In most cases, there is a business process that can be replaced with a cloud service to get a cheaper and a more effective way of doing a particular business process. That is why cloud computing is a good option since you do not have to worry about the technicalities as a user.

Currently, Cloud Computing is experiencing a strong adoption in the market and this trend is expected to continue. But without a well-defined adoption strategy to supports cloud computing capabilities, migrating towards cloud has no sense from the financial point of view because it leads to high costs with the re-engineering of existent systems. The prominent cloud adoptions strategies that are agreed in many experts and organizations have included the following phases as illustrated in the below.

- **The readiness of SMEs in the clouds-Needs and Requirements.**

This includes the needs of SMEs, requirements and desire to adopt cloud computing. These needs can be identified at various levels, for instance, the need for regulations and policy can be at the national, industry or even individual cloud consumer level. Literature that offers insight to these different levels of needs, requirements, as well as the readiness of the SMEs.

- **The processes of adoption of cloud computing for SMEs**

The adoption of cloud computing by SMEs presenting factors or determinants of SMEs adopt the cloud as well as studies that highlight the adoption process of SMEs, migration to the cloud, and

implementation and cloud integration issues. Processes of adoption include issues such as evaluation in terms of cost and cloud provider selection; adoption decision, integration and IT governance and usage and continuance issues.

4. Chapter Four: Proposed Framework

4.1 Background of the Framework

After assessing the current state of knowledge surrounding ICT usage in SMEs and these compared with existing approaches and then compiled into a comprehensive framework for a cloud adoption. Thus, in this section presented about the proposed a framework for cloud adoption that helps to efficiently utilize the potential of cloud computing as the latest information technology solution to add value for SMEs.

4.1.1 Need for a Framework for Cloud Computing Adoption

Traditional IT systems have been more complex and costly to maintain and are no longer able to meet business demands since they lack flexibility and scalability. Cloud computing is the answer to the problems that are currently being experienced by organizations that still have the traditional on-premise IT systems. Cloud computing saves costs by eliminating the need for high infrastructure expenses and also provides an easy to use, flexible, dynamic and secure environment for organizations to conduct their business.

Cloud computing combines multiple technologies and capabilities with a new business and operational model to create a new service delivery model. For these reasons, adoption of cloud computing carries architectural, financial and organizational impacts. Cloud computing enables IT to become a true service provider that efficiently supports the business needs of the organization.

Conversely, [60] raised some concerns with regard to using these services. He stated that vendor lock-in and failures are two main problems encountered when using the Cloud services. Many service providers offer their services through proprietary interfaces, and there are no Cloud Computing standards for APIs (Application Programming Interface), the storage of business data for recovery, and the import and export of data if businesses wish to change vendors. Additionally, the failure of a cloud vendor that stores the information can have a serious effect for the end users who trusted their data with their selected vendor.

4.1.2 Identifying Cloud Services and Deployment Models

In order to formulate a proper framework, we start with the identification cloud services and deployment model. There are a wide and increasing number of providers of "Cloud", and it is open to debate whether a particular offering comprehensively matches the set of characteristics that NIST or any other organization might use to distinguish a "pure cloud" offering from some technology. The rent of cloud services needs to decide what the required features are. It is apparent, however, the commercialization of software, software development and systems can offer alternative ways of doing "traditional" activities. Indeed, for some, IaaS, PaaS and SaaS could be used to replace a significant majority of extant IT systems entire businesses could run "in the Cloud".

- **Identifying Deployment Models**

There are several cloud deployment models are available. Firstly, the public cloud infrastructure, which is made available to the general public or a large industry group and is owned by an organization providing cloud services. Secondly, the private cloud infrastructure, which is operated and managed solely by an organization or it may be managed by a third party and may exist on premises or off premises. Thirdly, a hybrid cloud is a composition of two or more cloud environments, in which an organization provides and manages some resources in-house and has others provided externally through a public or community cloud.

By considering the knowledge derived from the literature and intention from the interviewee result the researcher decided to propose a hybrid cloud delivery model for SMEs. The formulation of a hybrid model, then, based on a range of variables, a specific institution's application, and infrastructure requirements. The proposed hybrid cloud model will have capabilities to combine cloud and non-cloud IT infrastructures such as private, shared and traditional IT within SMEs. The proposed hybrid delivery approach allows SMEs to accelerate speed-to-market by better aligning IT and the business itself. By integrating traditional IT and private cloud-based services with the new local cloud service provider, this hybrid approach protects current investments in SMEs. By leveraging flexible sourcing and usage-based pricing, it can help to reduce both capital and operating expenses of SMEs. This hybrid cloud formulation will reinforce vital risk and security management that were considered as the major barrios on

latest information technology adoption from using external public cloud service provider in SMEs.

- **Identifying the Type of Cloud-Based Services**

The cloud-based services were selected and identified based on the needs of the ICT environment for SMEs. The following sections discuss the three types of cloud services

Software as a Service (SaaS)

SaaS is one of the cloud-based services which enables user's access different software from the cloud wherever they are, and whenever they need without installing it on their machine [61]. In SaaS users can access different software from the cloud: SCM, CRM, E-mail, Virtual Desktop, Office applications, Enterprise Resource Planning (ERP) and different Business Information system applications, like core finance systems, HRM system.

Platform as a Service (PaaS)

Platform as a Service delivers a solution stack, which is an integrated set of software that provides everything a developer needs to build an application for both software development and runtime [62]. The proposed hybrid cloud will offer developer tools as a service to build services, or data access and database services on the cloud. The developers who seek to develop and run a cloud application for a particular platform can access these services using the interface presented to them. The developer interacts only with the platform through the proposed hybrid cloud interface, and the platform does what is necessary to manage and scale it to provide a given level of service. Using the cloud, developers do not need to physically install any specific services, solution stacks or databases on their machine. The hybrid cloud provides the following services for PaaS users: operating system and Storages (database and file storage).

Infrastructure as a Service (IaaS)

IaaS is another mechanism to deliver hardware such as servers, networks, data center space and others, which allows cloud users to host/run their data/applications on the provider computing infrastructure. The proposed hybrid cloud delivers these infrastructures using virtualization technology at one place to all SMEs. Under this cloud service model, the provider manages and maintains the hosting and the development environments. By consuming IaaS cloud SMEs can reduce infrastructure cost and complexity through its capabilities of rapid provisioning, ability to

scale up/down and pay only for what they use. The hybrid cloud provides the following services for IaaS users: Virtual machine, storage, network etc.

4.1.3 Selecting Cloud Service Providers

Organizations choose cloud deployment models for IT solutions based on their specific business, operational and technical requirements. Since the assessment allows to the enterprise to pick the right cloud solution. This study identified the potential cloud services such as IaaS, PaaS, and SaaS, while hybrid cloud deployment model is proposed for SMEs that could best meet the most business operation and service requirements of SMEs.

Identification and selection a proper cloud provider is the most important part of the implementation plan. Different providers may offer different service models, pricing schemes, audit procedures, and privacy and security policies. Also, it needs to evaluate the provider's standing and performance before it signs a contract.

Afterward, the researcher includes those clouds that afford a great amount of service. At the last stage, CSP selection was depending on the ease of the use and the existence of ongoing technical support services.

Cloud Computing has completely changed the conception of infrastructure architectures of a number of available resources and of development models. The physical servers are in fact split into virtual machines whose resources are flexible and scalable according to the requests made by users. In this way the same machine can be shared by multiple users and data can be fragmented in different locations. These characteristics raise important doubts about the security of these systems and the ability of properly governing the services provided.

4.1.4 Architectural Requirements for Cloud

In order to optimize the advantage of a cloud computing, the interfaces and architectures should allow a strong interoperability and accessibility to reach out the computing resources. The other important aspects that are critical for the architecture of a cloud computing are the security, scalability, availability, data migration, service level agreement, transparency, and much more [25] .

Within their paper, [25] .classify these aspects into three main groups of requirements: for end-users, enterprises that use the cloud, and the cloud provider itself. These requirements will be discussed briefly in the following points and incorporated with other supporting literature.

a) Provider Requirements

From the service provider's perspective, the key concerns are related to the efforts to make the cost model attractive, such as the necessity to have highly efficient service architecture and a well-organized and secure data storage mechanism. To fulfill these requirements, Service-oriented architecture (SOA) approach can provide a sort of architectural discipline that can help to leverage the cloud computing into a more effective and efficient IT infrastructure. These are the key requirements from the providers in which some of the attributes from SOA will also be described:

- **Service-centric issues.** The cloud services should be autonomic, self-describing, and efficient in the distributed composition. By being autonomic, the design of the cloud systems should enable a dynamic adaptation to the environmental changes with less human intervention. The self-describing service interface contains the information and functionalities which are reusable and loose coupled. With this loosely coupled and efficient composition, the interaction with multi-applications and collaboration would be easier. The transactions processed within these cloud services should conform to ACID properties – A (Atomic) that the transaction is completely done or never done; C (Consistent) that the database data integrity constraints are consistent from one state to another state; I (Isolation) that the data processing is not visible to other transaction requests until it is completed; and Durable that while the transaction is completed so does the update (Britton & Bye,
- **Interoperability.** This focuses mainly on the creation of an open data format or open protocol (API) to allow easy and secure interface, migration and integration of different clouds with different providers.
- **The quality of service.** The certain level of service attainment is established in order to guarantee a sufficient performance and availability, as well as the other quality aspects such as the security, dependability, reliability, etc.

- **Fault tolerance.** The faults can be isolated only to the falling components and prevent the other services affected. For this, proper tools and mechanism such as a certain application for self-healing and self-diagnosis are necessary.

The other requirements that require careful treatments are the data management and storage to ensure the data replication across geographic distances along with its availability and durability, virtualization management to handle the virtual machines on the top of its operating system, scalability to deal with a large set of data operation in cloud, and lastly the load balancing to have a self-regulating mechanism to monitor the workload property within the cloud.

b) **User requirements.** The major issues coming from the end users are the privacy – how to ensure the sensitive data stored in cloud protected from misuse, the service level agreement – whether the cloud service provider is able to deliver the services accordingly with the pre-defined agreements, the adaptability, and learning – the supports to make the users feel acquainted with the cloud systems, and the user experience – to provide insights to users that can help them to understand the capacity, usability, desirability of the applications.

c) **Service Level Agreement:** The benefits offered by resource scalability and pay-as-you-go approach contrast with the low standardization and the continuous change of systems. Therefore, to ensure quality and continuity of service, a clear Service Level Agreements (SLA) between consumers and providers is critical. The lack of a precise set of metrics complicates management, especially when services are across many providers. Other factors, as trust in the cloud providers, become important to companies that are clouding critical data.

The research concerning SLAs, such as the Quality of Service (QoS) metric, template, frameworks has been widely conducted by the researchers, mainly for service-oriented related architecture. However, the same research for cloud computing is not available in the same amount. SLA metrics from such architecture and technologies are not directly suitable for cloud because its nature and resources being delivered are different. The key properties that should be documented within the SLAs are as the following:

- A clear description of the service
- The level of expected performance of the service

- The service parameters to be monitored and the format of monitoring exports
- Penalties when the service requirements are not achieved

Functional and non-functional requirements for cloud customers. These requirements set the expectations toward the cloud services and should be fulfilled by the providers. The nonfunctional requirements can be the source for criteria in SLAs, such as:

- **Availability** – the probability that the cloud services are available in the specific time of utilities.
- **Scalability** – the specific resources are provided in order to facilitate the ease of scaling up and down.
- **A clear cost calculation method** – since the billing is based on the utilization of the cloud services, a certain mechanism should be established in order to allow the customers trace their use.
- **The configuration of service** – the cloud services can be configured in a flexible manner in order to minimize the system changes performed by the customers.
- **Security and privacy** – the sufficient protection of the critical data by the cloud service providers.

4.2 Building the Framework

According to the analysis result of this study showed that the existing Information Communication Technology (ICT) investment and usages in the small and medium enterprise (SMEs) in Ethiopia were described as insufficient. Propose an efficient ICT investment and usage strategy to support the SMEs activities by recent technological model i.e. cloud computing model. This Cloud-based service helps to solve limitations of the current ICT usage in SMEs.

Through taking these into account the researcher decided to propose hybrid cloud model for `SMEs. The proposed local cloud service provider will be formed and equipped with essential cloud technology infrastructure that can be a provision as a service to SMEs based on their specific IT infrastructure requirements using cloud computing business model. This cloud provider will provide scalable, elastic and reliable resources to the users. This cloud service provider creates virtual computing resources out of physical computing resources and allocates

the virtual computing resources to different users. This means that multiple users share common physical computing resources.

The cloud-based services offered by the proposed cloud service providers could be:

1. **IaaS** which deliver infrastructure resources includes servers, storage, and networking.
2. **PaaS** which offer developer tools as a service to build services like operating system database system.
3. **SaaS** which delivers domain-specific applications or services over the Internet including collaboration and communication tools, Office applications, and different business Information system applications (like Accounting software, HRM system) and other Application Software can be hosted.

Therefore, the proposed hybrid cloud model allows users to run the different workloads on local cloud service provider infrastructure or platform services.

The Proposed framework namely Ethiopian Small and Medium Enterprise Hybrid Cloud (ESMEHC).It is a set of common and shared services and contains four layers (User Interface, SaaS, PaaS, and IaaS) and three modules (User log database, system security, and service management): Based on the identified and selected clouds-based services, the researcher proposed a Cloud Computing framework Ecosystem for SMEs providers. The next figure shows a general layout of the Ethiopian small and medium enterprise Cloud Ecosystem based on the cloud computing with an interface layer to control the user's access to different services. Virtually the cloud services can be deployed and run on the proposed service provider physical IT infrastructures. Users of cloud services are employees, customers, partners, suppliers and others users of the SMEs. Ethiopian Small and Medium Enterprise Hybrid Cloud (ESMEHC) have an interface for others cloud service provider. Users can store their data and access virtual machine instances (software containers) on cloud computing infrastructure easily.

Users can create virtual machine image, launch the required services and terminate the virtual machines through cloud interface. Computing resources will not exit but functions by creating a virtual version of an IT resource such as OS, a server, Storage device and Network resource on rent base when needed.

Based on the identified cloud services model discussed in the above framework background, the researchers proposed a collaborative cloud computing architectural framework for SMEs. The following figure shows the proposed Ethiopian small and medium enterprise cloud framework.

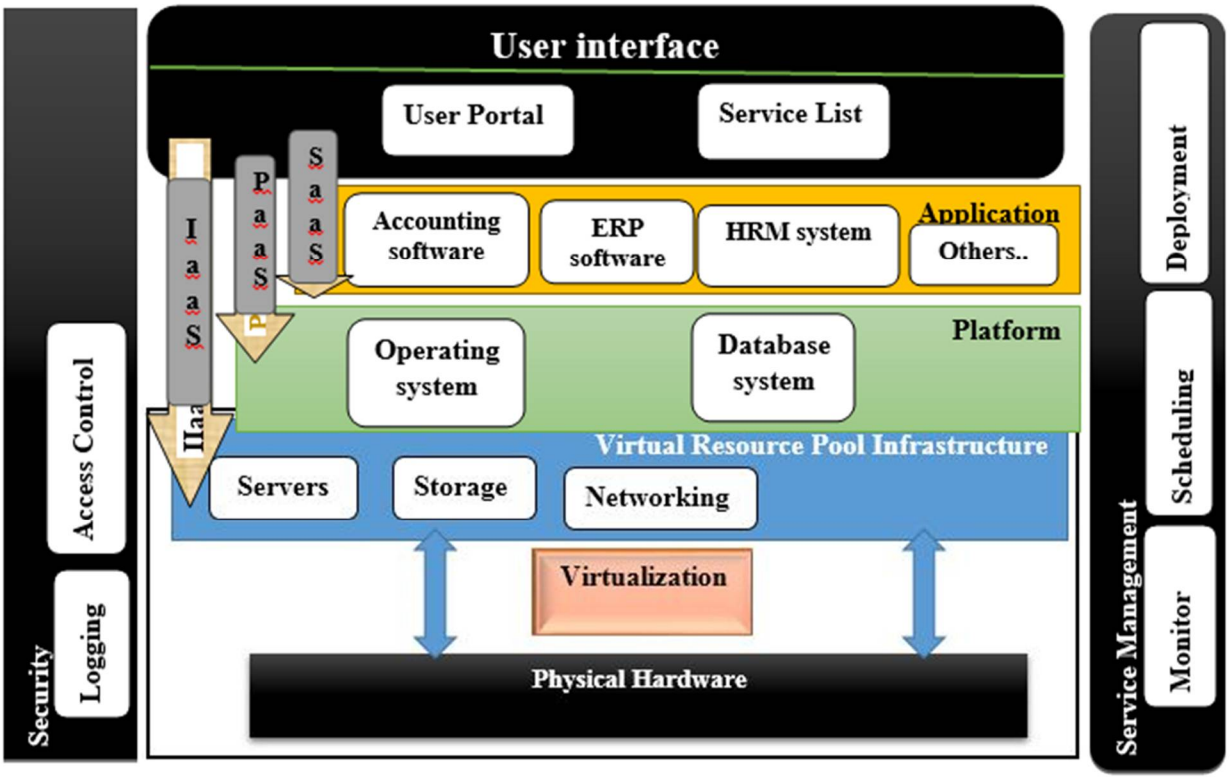

FIGURE 10: PROPOSED HIGH-LEVEL CLOUD-BASED SERVICE DELIVERY ARCHITECTURE

4.2.1 User Interface Layer:

This layer acts as an interface between the user and the cloud content. Access to each cloud services is protected by the Authentication and Authorization mechanism because applications and data are hosted outside of the organization in the cloud computing environment. This allows users to access the cloud services in a security-rich environment.

Authentication means that each user has an identity which can be trusted as genuine. This is necessary because some resources may be authorized only to certain users, or certain classes of users. Authentication is the mechanisms whereby systems may securely identify their users. Authentication systems provide answers to the questions: Who is the user?

Authorization is the mechanism by which a system determines what level of access a particular authenticated user should have to secure resources controlled by the system.

Generally, this layer contains two important components.

- **User Portal:** 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. Login, Registration & Administration
- **Service list:** provides the list of the available services in the cloud environment

4.2.2 Software Service Layer:

This layer provides access to hosted programs–applications or tools on the Cloud. Accounting software, HRM system, ERP software and other Application Software can be hosted at this layer.

4.2.3 Platforms Service Layer:

This layer provides access to application hosting and development environments including operating systems and database systems another platform services.

4.2.4 Infrastructure Service Layer:

This layer offers more flexibility when dealing with the hardware layer through virtualization including servers, storage, and networking on the cloud environment. The users can consume the services virtually with buying it from the proposed SMEs infrastructure service providers. The user can use these computing resources to run software (both operating systems and applications) and to store data.

4.2.5 Service level management

Additionally, the proposed framework has system security module for maintaining the security of the cloud, service management module for monitoring, scheduling, and deployment of services. The monitoring service can also be used by users to measure the performance of provisioned virtual machines and to determine whether new virtual machines need to be started. In a cloud system, everything is metered and accounted. Metered usage information provides for

flexible pricing and charging in a cloud environment. Historic usage information together with monitoring information is critical to automate capacity planning and ensured agreed on QoS.

4.3 Development plan for the Proposed Framework

The proposed framework will utilize IT infrastructure of the enterprise which would adapt the framework namely, Ethiopian Small and Medium Enterprise Hybrid Cloud (ESMEHC) as illustrated above. In such a situation, the framework needs to deploy a hybrid cloud model as a cloud-based solution for SMEs, which combines the local infrastructure as a private cloud with selected public clouds. Hybrid Cloud is one of the Cloud Computing deployment models. It provides the ability to access, manage, and use third-party (vendors) resources from multiple CSPs and combines them within in-house infrastructure (private Cloud). Using such a model allowed us to avoid lock-in and was blocked with one CSP by allowing mix and match services from different CSPs. In addition, it will give us the ability to secure the company's critical application and data by hosting them on the private Cloud without having to expose them to a third-party. With a hybrid Cloud model, the enterprise has more control of their system since part of the infrastructure is under their control. For this model, the research needs software which manages the complexities and the heterogeneity of this distributed data centers. So the researcher tries to professionally compare and select the different open source cloud infrastructure manager tools. The contest is among OpenNebula, Eucalyptus, OpenStack, and CloudStack.

4.3.1 The Choice of Cloud Computing Projects

Open Source software generally gives preference to that program which is having source code available for others to use or modify other than that of original developers [63]. Open Source Cloud Computing is a great combination of the cloud features such as lower service costs, economically affordable and having better resource sharing ability and the Open Source features such as making the source code fully available unlike to that of proprietary approach. That's Why Open Source Cloud computing is being popular among the developers as well as end-users [64] [65] [66].

There are many open source cloud computing projects, and the mainstreams are OpenNebula, Eucalyptus, OpenStack, and CloudStack.

OpenNebula [67], sponsored by the Institute of European Studies in 2005, is an open implementation of virtualization management layer of the virtual infrastructures and the cloud computing plan. It is divided into three layers, namely, the interface layer, the core layer and the drive layer. The interface layer provides a native XML - RPC interface, at the same time, realizes many kinds of API like EC2, OCCI and OpenNebula Cloud API (OCA) and so on, and provides to users a variety of choices. However, OpenNebula does not adopt SOA design, and not design computing, storage, and network as individual components, so the decoupling degree is not enough.

Eucalyptus [68] is an open source IaaS among the first to try to clone the AWS platform, composed of the cloud controller (CLC), Walrus, cluster controller (CC), storage controller (SC) and the node controller (NC), together with collaborating to provide the required cloud services. Components use SOAP messages supporting WS-Security to achieve secure communication. Cluster control lets computing service and storage service become independent, but the network is still part of the computing services. Although the network is part independent on code implementation, but overall is not designed as independent services, so the decoupling of the overall design is not enough.

CloudStack [69] is an open source IaaS software exploited by Cloud.com and is divided into community edition and commercial version. In 2011, Citrix System Company acquired Cloud.com and turned it into a fully open source projects. CloudStack is a typical layered architecture, including the Dashboard/CLI layer, CloudStack API, the core engine layer and computing/storage/network controller layer. But CloudStack itself does not adopt the design of the SOA, and it also does not separate calculate/storage/network parts from the core engine, so it needs to be further strengthened in the aspects of loose coupling and component designing.

OpenStack [70] is an open source cloud computing platform project, which is cooperatively studied by the U.S. national aeronautics and space administration (NASA) and Rackspace. Since 2010, it has released nine versions, and the latest version is the Icehouse. After the Folsom version, storage EBS (Elastic Block Service) and Network are independent of computing Service (Nova) and become the new service (block storage service “Cinder” and net service “Quantum”). Nova calls the cinder and Quantum services through the API. Obviously, OpenStack is the best on SOA and decoupling service components.

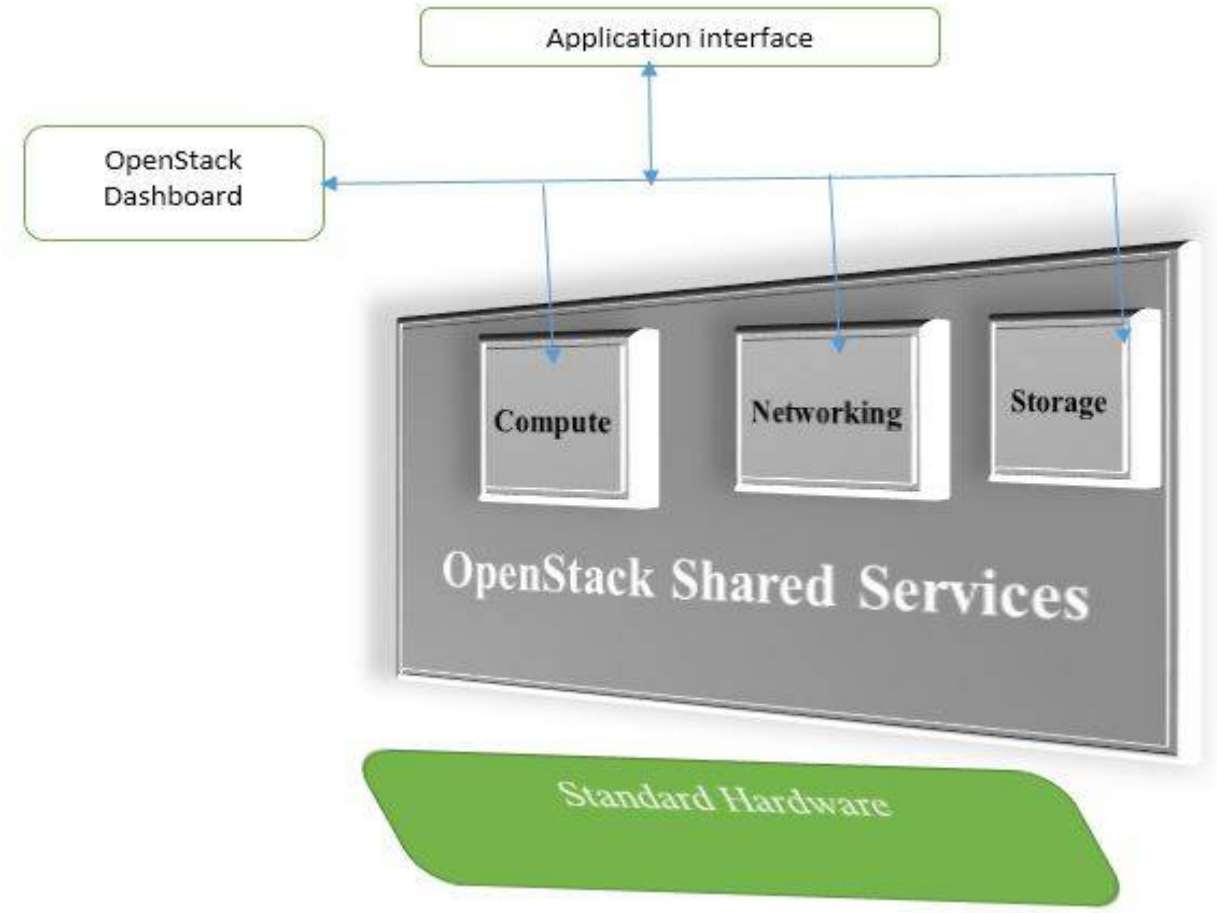

FIGURE 11: THE OPENSTACK COMPONENT AS OF THE JUNO (OCTOBER 2014):

OpenStack main characteristics are that is:

- **Scalable:** This solution is already deployed worldwide in companies whose data volumes is measured in terabytes of distributed architectures and massively scalable up to 1 million physical machines, up to 60 million virtual machines and billions of stored objects [71].
- **Compatible and Flexible:** OpenStack supports most virtualization solutions of the market: ESX, Hyper-V, KVM, LXC, QEMU, UML, Xen and XenServer [29].
- **Open:** Being an open source technology, the entire code can be modified and adapted as needed.

Therefore, OpenStack is the choice to realize the construction of private cloud in this paper because of its characteristics. OpenStack is open source software which anyone can use to build

both private and public cloud [27] . The aim of OpenStack is "to produce the ubiquitous open source cloud computing platform that will meet the needs of public and private clouds regardless of size by being simple to implement and massively scalable" [28] .

4.3.2 OpenStack Architecture

OpenStack has five subprojects, namely Compute, Object Storage, Image Service, Identity, and Dashboard, among them, the core subprojects are Compute, Storage, and Image. The computer is the cloud group controller, which provides a tool to deploy the cloud, including running instance, managing network, and controlling the access to the cloud of users and other projects. Its bottom open source project name is Nova, whose providing software can control the IaaS cloud computing platform, similar to AmazonEC2 and Rackspace Cloud Servers [27] .

Storage is a scalable object storage system, and Swift component is its concrete implementation. It provides the distributed cloud storage services, supports a variety of applications of its object storage, and realizes the multi-node distributed storage management of cloud files. The image is a mirror storage, query, and retrieval system of virtual machines, and Glance component is its concrete implementation. It can be configured in three forms: using OpenStack’s object storage mechanism to store the mirror; using the Amazon's simple storage solution (S3) to directly store information, or combine S3 storage and object storage as the connector of S3 access. OpenStack mirror service supports for many virtual machine image formats, including VMware (VMDK), Amazon mirror (AKI, ARI, AMI) and various disk formats supported by VirtualBox. Image metadata container formats include AKI, ARI, AMI, standard OVF format and binary large data [72]

In addition, Identity and Dashboard are implemented by Keystone component and Horizon component, and Keystone provides a unified Identity authentication service, and Horizon provides to the user to use cloud services platform by a Web front-end interface, through which, users can carry out the secret key and roles permissions of mirror instances and cloud storage management, etc. Quantum, OpenStack Virtual Networking, and Atlas, OpenStack Load Balancer [72].

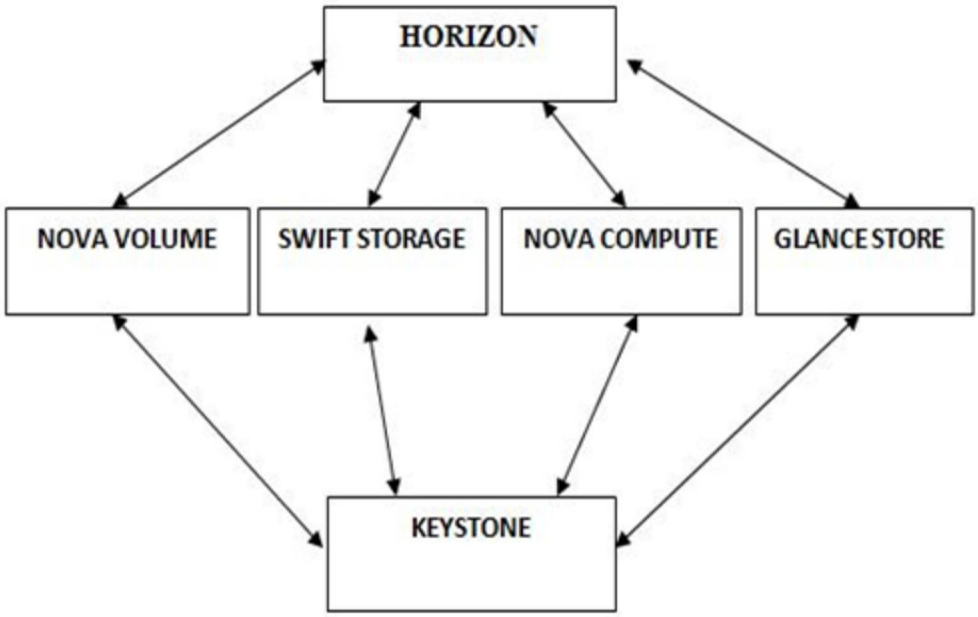

FIGURE 12: ARCHITECTURE OF OPENSTACK [73]

- ***Nova:*** Nova is the Computing Fabric controller for the OpenStack Cloud. The necessary activities for the lifecycle of instances within the OpenStack cloud are handled by Nova. This characteristic makes Nova a Management Platform manage various compute resources, networking, authorization, and scalability needs of the OpenStack cloud.
- ***Glance:*** Glance is a standalone service which provides a catalog service for storing and querying virtual disk images. Nova and Glance together provides an end-to-end solution for cloud disk image management.
- ***Swift:*** Swift can store billions of virtual object distributed across the nodes. The swift offers built-in redundancy, failover management, archiving and media streaming. Swift plays an important role in scalability.
- ***Keystone:*** Keystone provides identity and access policy services for all components in the OpenStack family. All components of OpenStack including Swift, Glance, and Nova are authenticated and authorized by Keystone.
- ***Horizon:*** Horizon can be used to manage instances and images, create keypairs, attach volumes to instances, and manipulate Swift containers.

The next figure shows an overview of the proposed Hybrid Cloud Computing model for Ethiopian Small and Medium Enterprise.

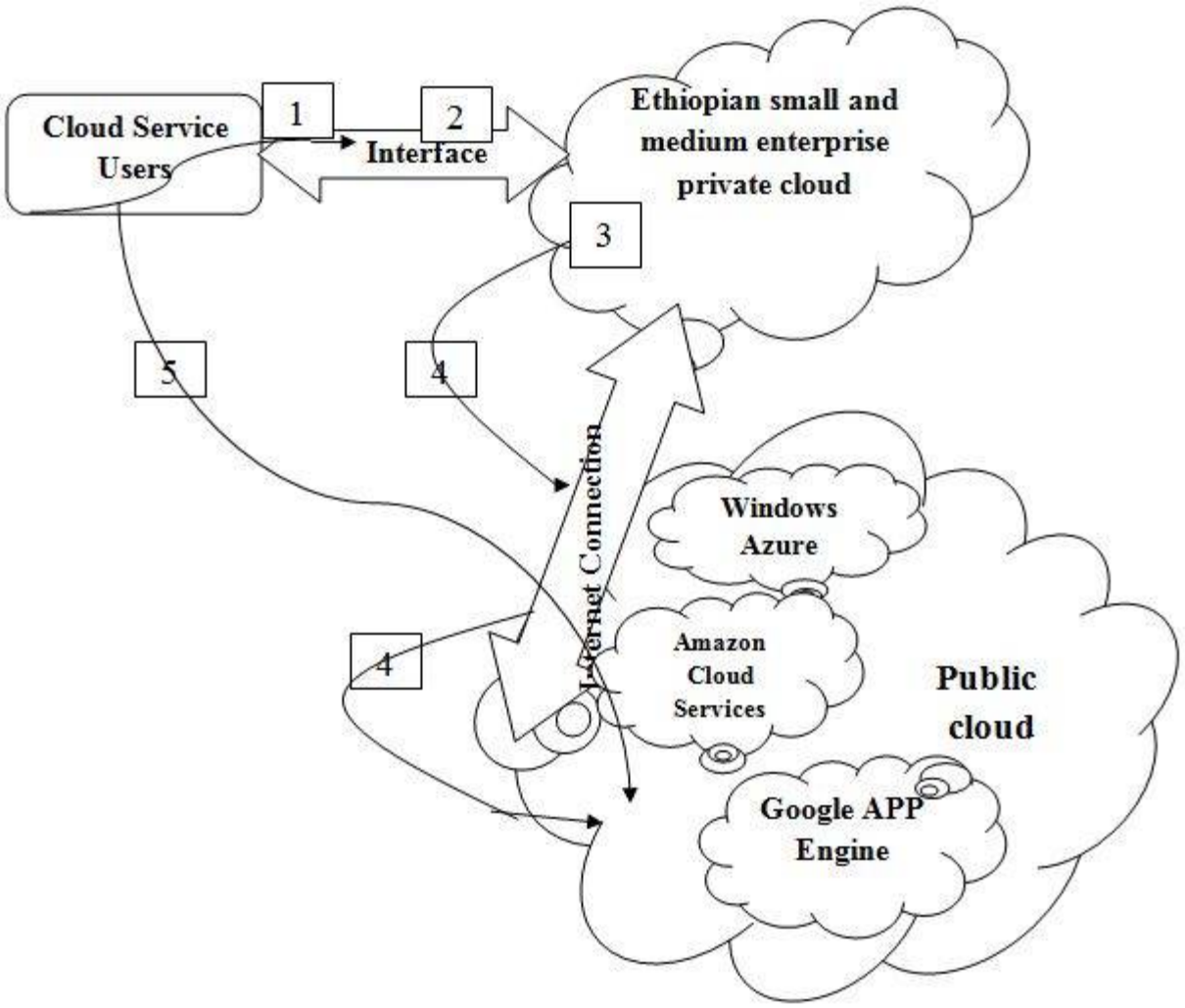

FIGURE 13: AN OVERVIEW OF PROPOSED A HYBRID CLOUD FOR ETHIOPIAN SME

The figure above shows an overview of the selected Cloud and how the content could be arranged in the private Cloud. Within six steps, the user can use a resource and then release it; these steps are illustrated in the following points:

1- The user sends a request using the ESMEHC interface

2- The verification of the authorization level will be checked using the user profile private Cloud.

3- If the user is unauthorized to request such services, the system will reject the user's request; otherwise, the request will be sent to the virtual infrastructure manager(OpenStack) to redirect the request to the appropriate location for either public or private Clouds.

4- The system will establish a connection between the requested services from the Cloud and the user.

5- As long as the user needs the resource and does not exceed the maximum usage period, the system synchronizes the service delivery between the user and the resource.

6- When the user is done and no longer needs the requested resource, the system will terminate the session and disconnect the user from the target Cloud.

5. Chapter Five: Demonstration and Evaluation

Implementation of a prototype details serves as a demonstration of the approach. The proposed work involves the implementation of a prototype private cloud setup with an open source cloud software platform which can provide a well-structured tool for the cloud management and complete server and storage virtualization, from such tools the study used such as OpenStack and XenServer. The evaluation of performance of the proposed work with Infrastructure-as-service configuration.

5.3 Prototype for Proposed Hybrid Cloud Implementation

In the previous chapter we have proposed high-level cloud-based service delivery architecture, these implemented using various open source technology. As the prototype is completely developed in the open source environment, most of these tools were downloaded from the internet and installed from source codes. The documentation that comes with most of the open source software was used to install and customize the modules.

Private cloud is a virtual IT infrastructure that is controlled and operated by the organization. OpenStack and Xen virtualization open source technology is adapted to the construction of private cloud in this paper because of the characteristics they have. For building a private cloud using Open Stack is introduced which is capable of serving the user request for infrastructure and platform services. The next figure shows an overview of the proposed Hybrid Cloud Implementation Architecture based on OpenStack and Citrix XenServer for the proposed framework

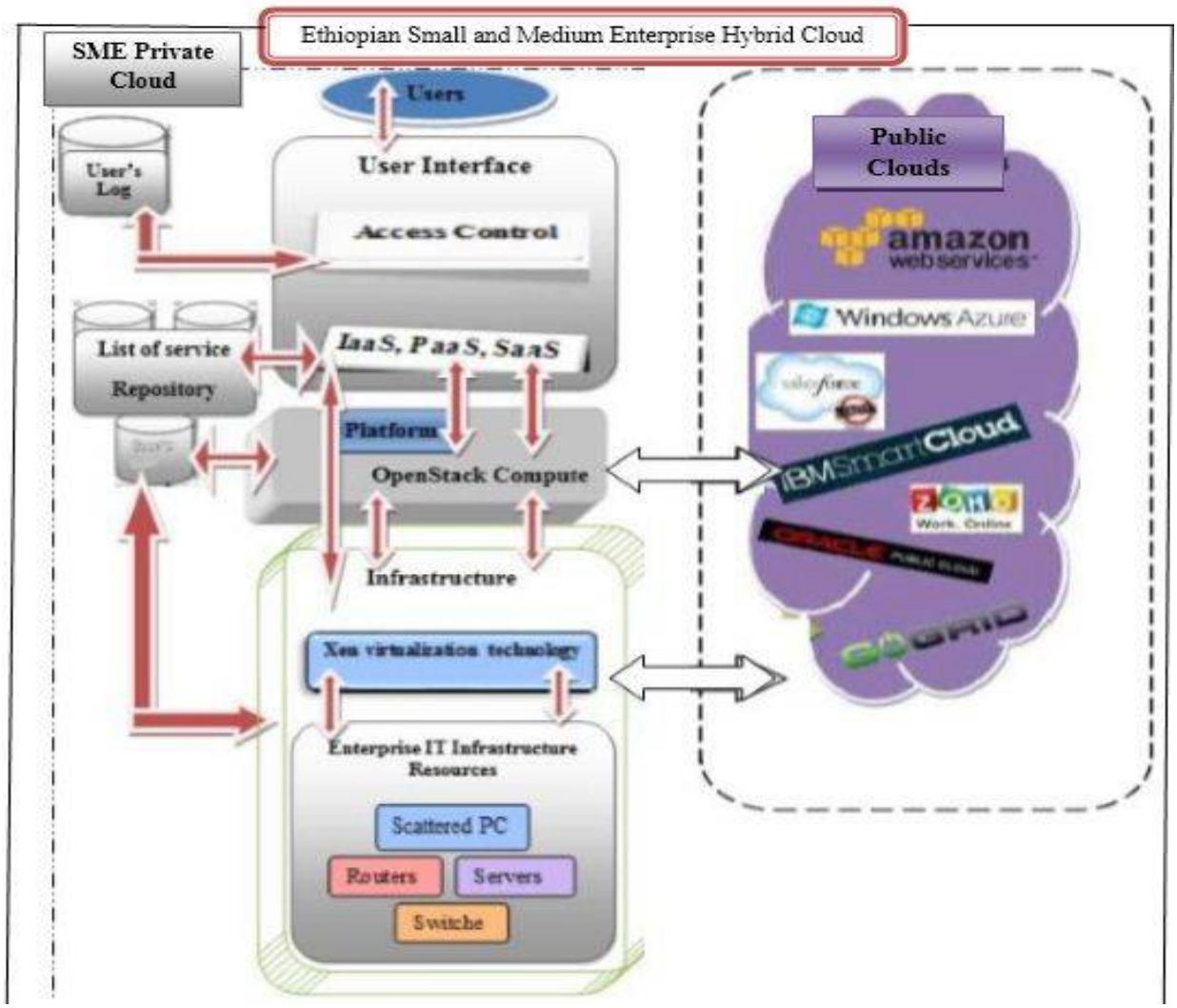

FIGURE 14: ETHIOPIAN SMES PROPOSED HYBRID CLOUD IMPLEMENTATION ARCHITECTURE BASED ON OPENSTACK AND XEN VIRTUALIZATION TECHNOLOGY (DESIGN BY THE RESEARCHERS)

The following list describes about implemented of the proposed hybrid cloud architectural framework components:

5.3.1 Infrastructure layer:

In the IT Infrastructure will be placed at the bottom of this layer since Ethiopian SMEs private Cloud would be built on top of the available infrastructure. Furthermore, these physical infrastructures will be virtualized using XenServer which plays a critical role in the infrastructure

layer. XenServer is a complete server virtualization platform, optimized for both Windows and Linux virtual servers, with all the capabilities required to create and manage a virtual infrastructure.

Enterprise private cloud is built on a computer cluster of multiple physical machines. Physical resources in the system include computer nodes like enterprise servers and scattered PC, as well as switches and routers. XenServer works by abstracting elements from the physical machine (such as hard drives, resources, and ports) and allocating them to the virtual machines running on it. A virtual machine (VM) is a computer composed entirely of software that can run its own operating system and applications as if it were a physical computer.

A VM behaves exactly like a physical computer and contains its own virtual (software-based) CPU, RAM, hard disk and network interface card (NIC). The system can also recycle these virtual resources and realize start, stop, migration and recovery management of the virtual machine. This layer is transparent to users, and there is no difference between the virtual machine and the general physical machine to users. When making virtual images, software and services also can be customized. So that the benefits:

Using XenServer reduces costs by:

- Consolidating multiple VMs onto physical servers
- Reducing the number of separate disk images that need to be managed
- Allowing for easy integration with existing networking and storage infrastructures

Using XenServer increases flexibility by:

- Allowing to schedule zero downtime maintenance by using XenMotion to live to migrate VMs between XenServer hosts
- Increasing availability of VMs by using High Availability to configure policies that restart VMs on another XenServer host if one fails
- Increasing portability of VM images, as one VM image will work on a range of deployment infrastructures

There are two methods by which to administer XenServer: XenCenter and the XenServer Command-Line Interface (CLI).

- **XenCenter** is a graphical, Windows-based user interface. XenCenter allows you to manage XenServer hosts, pools and shared storage, and to deploy, manage and monitor VMs from your Windows desktop machine.
- **XenServer Command-line Interface (CLI)** allows you to administer XenServer using the Linux-based xe commands.

5.3.2 Platform layer:

The platform layer is the core part of private cloud management platform, and use OpenStack compute to complete cloud organization and deployment. Platform architecture designs the management system and mirror system. Management system completes the management of the virtual machine and the user.

Devstack mission is to provide and maintain tools used for the installation of the central open-stack services from source suitable for development and operational testing. Devstack is an opinionated script to quickly create an OpenStack development environment. It is also used to demonstrate starting and running OpenStack services. Devstack has evolved to support a large number of configuration options and alternative platforms and support services. Devstack is downloaded and installed to utilize the OpenStack services.

Cloud Controller Node–Runs the Identity service, Image service, and dashboard and management portion to the computer. It also contains the associated Application programming interface services, MySQL databases, and messaging devices. *Compute Node* – Runs the hypervisor portion to compute virtual machine. Compute also provisions and operates tenant network and implement security groups. It can run more than one compute node. If there is more than two compute nodes, network service is needed.

Moreover, it is would be connected to the Service Repository module to integrate the OpenStack platform service with different services.

5.3.3 User Interface layer:

This layer is controls and managed by the ESMEHC's hybrid Cloud, identifying the access model which could be an employee, customer, administrator, partners, supplier or others which

can be created by the system's administrator. The authorization and identification process will be done using the Users Logs module to verify the entered information. Then it forwards the users' request to the appropriate component in the same layer. Furthermore, this layer has three other components: IaaS, PaaS, and SaaS. IaaS provides a resource from the Infrastructure layer. A middleware container is used to develop applications and give learners and educators the access to PaaS services provided by the PaaS component in the user Interface layer which provides an access to the Platform layer that contains the OpenStack platform. Lastly is the SaaS component which provides access to either the Platform layer so as to use one of the deploy applications or to public Clouds which may host an application used by system users, such as e-mail. There is a certain level of QoS which is granted by the provided SLA which includes detailed information about the services and available levels of resources to be accessed. This multi-layer in the ESMEHC hybrid Cloud architecture offers additional levels of security for the presented system.

5.3.4 Service Repository Module:

This consists of different services, accounting software, HRM system, ERP software, such as database systems, Web file system and so on. This module could contain specific details about services.

5.3.5 Users Logs module:

This is mainly responsible for checking the track of the authorizations users and it's access mode which is selected in the User Interface layer. Users' information is stored in the Users Logs module, such as access modes, user account name, password, user type, and so on. Moreover, this module manages and supports resource utilization by recording the resource requirements and their status.

5.4 Experiment Setup

In the chapter one, the necessary tools are identified for designing and implementing the proposed architectural framework. This section describes to test our implemented prototype of the proposed architectural framework. Open source solutions are already driving innovation and capturing the cloud market, rapidly improve the proprietary software in cloud infrastructures. An

open source XenServer with OpenStack meets the expectations of cloud builders for source code availability, open APIs and ecosystem contribution and integration. The detail installation steps explained in Appendix B.

The experimental steps through installing the XenServer host software on physical servers, installing XenCenter on Windows workstations and finally connecting them to form the infrastructure for creating and running Virtual Machines (VMs). ESMEHC's private cloud will have the ability to be connected to the public cloud at the peak time. In addition, the user can request any needed service from the public cloud at any time, which results in ESMEHC hybrid cloud.

A Xen host runs a number of virtual machines, VMs, or domains (the terms are synonymous on Xen). One of these is in charge of running the rest of the system and is known as domain 0, or dom0. It is the first domain to boot after Xen and owns the storage and networking hardware, the device drivers, and the primary control software. Any other VM is unprivileged and is known as a domU or guest. All customer VMs are unprivileged, but you should note that on XenServer (and other XenAPI using hypervisors), the OpenStack Compute service (nova-compute) also runs in a domU. This gives a level of security isolation between the privileged system software and the OpenStack software (much of which is customer-facing).

Our aim is to set up an experimental for demonstrate the developed prototype of private cloud using the open-source software Citrix XenServer/XenCenter and understand the tools and services provided by OpenStack for deploying Infrastructure-as-a-Service cloud model. The different steps involving in OpenStack and Citrix XenServer/XenCenter are:

1. Assessing and establishing the IT Resources server.
2. Creating Virtual Machines (VMs) and configuring the virtualization layer.
3. Evaluation of performance of the proposed work

5.4.1 Citrix XenServer/XenCenter Installation

XenServer requires at least two separate physical x86 computers: one to be the XenServer host and the other to run the XenCenter application. The XenServer host computer is dedicated entirely to the task of running XenServer hosting VMs and is not used for other applications.

The computer that runs XenCenter can be any general-purpose Windows computer that satisfies the hardware requirements and can be used to run other applications.

System Requirements

TABLE 5.1 SYSTEM REQUIREMENTS FOR THE XENSERVER HOST

CPU	RAM	DISK SPACE	SYSTEM TYPE
One or more 64-bit x86 CPU(s), 1.5GHz minimum, 2 GHz or faster multicore CPU Recommended	2GB minimum, 4GB or more recommended	46GB of disk space minimum, 70GB of disk space recommended	Ubuntu server operating system

TABLE 5.2 SYSTEM REQUIREMENTS FOR XENCENTER

Operating System	Windows 8.1, Windows 8, Windows 7 SP1, Windows Vista SP2, Windows Server 2012R2, Windows Server 2012, Windows Server 2008R2 SP1, Windows Server 2008 SP2
.NET Framework	Version 4.5
CPU Speed	750MHz minimum, 1GHz or faster recommended
RAM	1GB minimum, 2GB or more recommended
Disk Space	100MB minimum
Network	100Mb or faster NIC
Screen Resolution	1024x768 pixels, minimum

The steps through installing the XenServer host software on physical servers, installing XenCenter on Windows workstations and finally connecting them to form the infrastructure for creating and running Virtual Machines (VMs).

The XenServer host consists of:

- The **Xen Hypervisor**: The hypervisor is the basic abstraction layer of software. The hypervisor is responsible for low-level tasks such as CPU scheduling and is responsible

for memory isolation for resident VMs. The hypervisor abstracts from the hardware for the VMs. The hypervisor has no knowledge of networking, external storage devices.

- The **Control Domain**: Also known as 'Domain0', or 'dom0', the Control Domain is a secure, privileged Linux VM that runs the XenServer management toolstack. Besides providing XenServer management functions, the Control Domain also runs the driver stack that provides user-created Virtual Machines (VMs) access to physical devices.
- The **management toolstack**: Also known as **xapi**, this software toolstack controls VM lifecycle operations, host and VM networking, VM storage, user authentication, and allows the management of XenServer resource pools. xapi provides the publicly documented XenAPI Management Interface which is used by all tools that manage VMs and resource pools.
- VM templates, for installing popular operating systems as VMs.
- A local Storage Repository (SR) reserved for VMs.

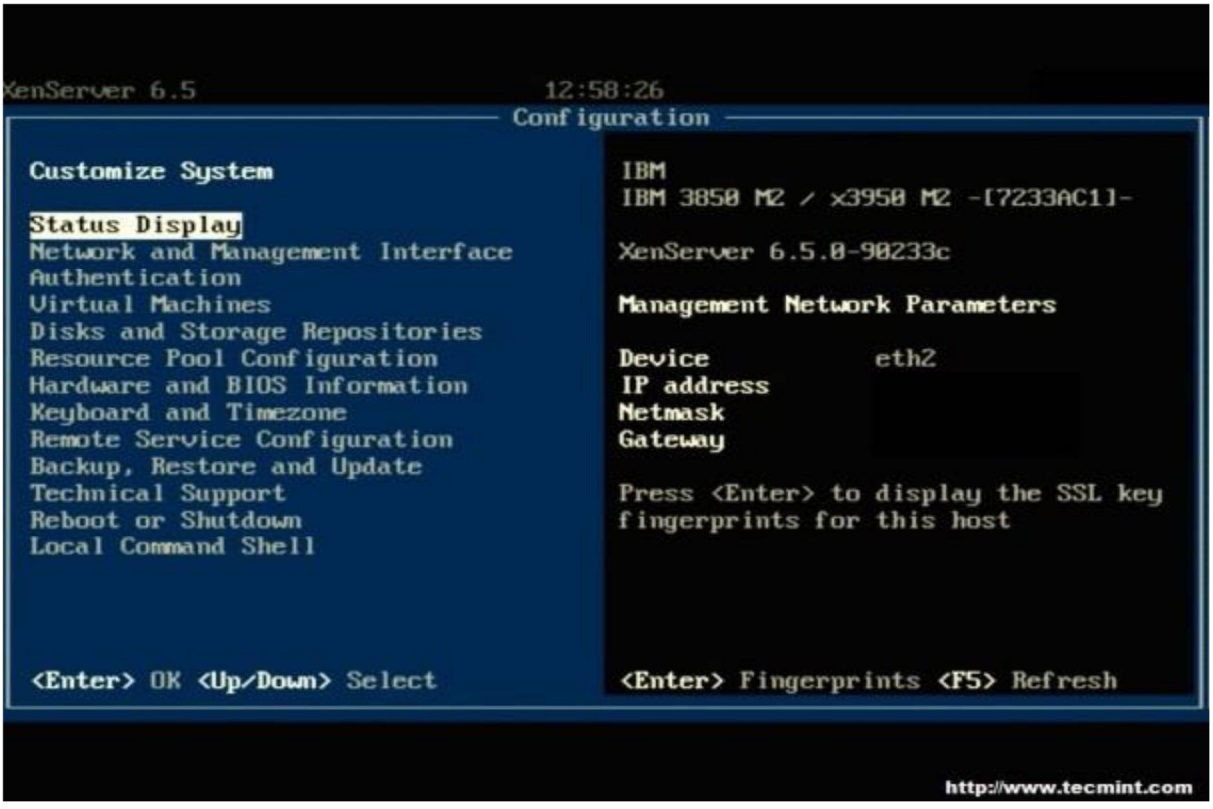

FIGURE 15: XENSERVER SYSTEM DETAILS

5.4.2 Creating Virtual Machines (VMs) and configuring the virtualization layer

New virtual machines can be created either from operating system CD/DVD, ISO or existing templates provided by XenServer. When connected through XenCenter to the XenServer host templates are listed left side of the panel. Here a NFS server has been created to hold all necessary ISO required by an organization and that has been attached to pool. When a new virtual machine will be created all the desired ISO will be available. The VM creation process broadly consisting of allocating RAM, CPU and storage from NFS Share and then network interface for accessing the VM. After this VM will run and OS can be installed as like as a physical installation. After this according to requirement stacks will be created.

The XenServer 6.5 enables provisioning and re-provisioning of the shared pools of servers, storage, power, and network connectivity as needed, based on pre-defined templates. Typically, each template represents the complete infrastructure needed to host a specific application service, such as Windows XP, Windows 7, Windows 8, Windows Server 2008, or even a custom application such as MIS (Management Information System).A XenServer 6.5 administrator uses a graphical user management interface, XenCenter to build and publish these infrastructure service templates. Using XenCenter, users can view a catalog of published service templates and request an instance of a service to be automatically provisioned.

We can deploy a single XenServer 6.5 environment in place of multiple different server configurations to satisfy varied application requirements for CPU, memory, network, and storage and quickly build our private cloud. Physical Server resources are then available on demand as infrastructure services for IT users to request using a service catalog. An administrator can use the management console, XenCenter, to define pools of servers, network, and storage resources to support infrastructure services. Through the console, the administrator can also define virtual machine images and software deployment jobs, register user accounts, and assign resource pools to users

5.4.3 Evaluation of performance of the proposed work

Open source solutions are already driving innovation and capturing the cloud market, rapidly outpacing proprietary software in cloud infrastructures. Underpinning the evolution of XenServer for cloud enablement was the move to make it fully open source. An open source XenServer aligns with the OpenStack Platform meets the expectations of cloud builders for source code availability, open APIs and ecosystem contribution and integration. [29].

Performance testing techniques allow us to measure the cloud system performance accuracy. Performance is generally tied to an application's capabilities within the cloud infrastructure.

These were launching measured virtual machines with CPU per actual processor core. The study used Ubuntu 12.4 server image and launched the virtual machines with 1 CPU and 2GB of memory. Maximum memory consumption would have been 28GB leaving 4GB to the operating system and cloud software.

Measuring launch time was straightforward. We knew at what time we had started the process. We can say that Ubuntu server is running when we can log in with ssh. Ubuntu logs all the boot activity including launch of SSH daemon to /var/log/boot.log. All we had to do is to log in with ssh and take the timestamp of this _le. The time di_erence gives us the needed launch time. Launch of single VM took less than two minutes.

Monitor metrics for all the virtual machines in XenServer pools automatically as new VMs are added and deleted. In the graphs that displayed below identify virtual machines CPU, memory usage, and network performance that gathered in host performance data under XenCenter performance tab.

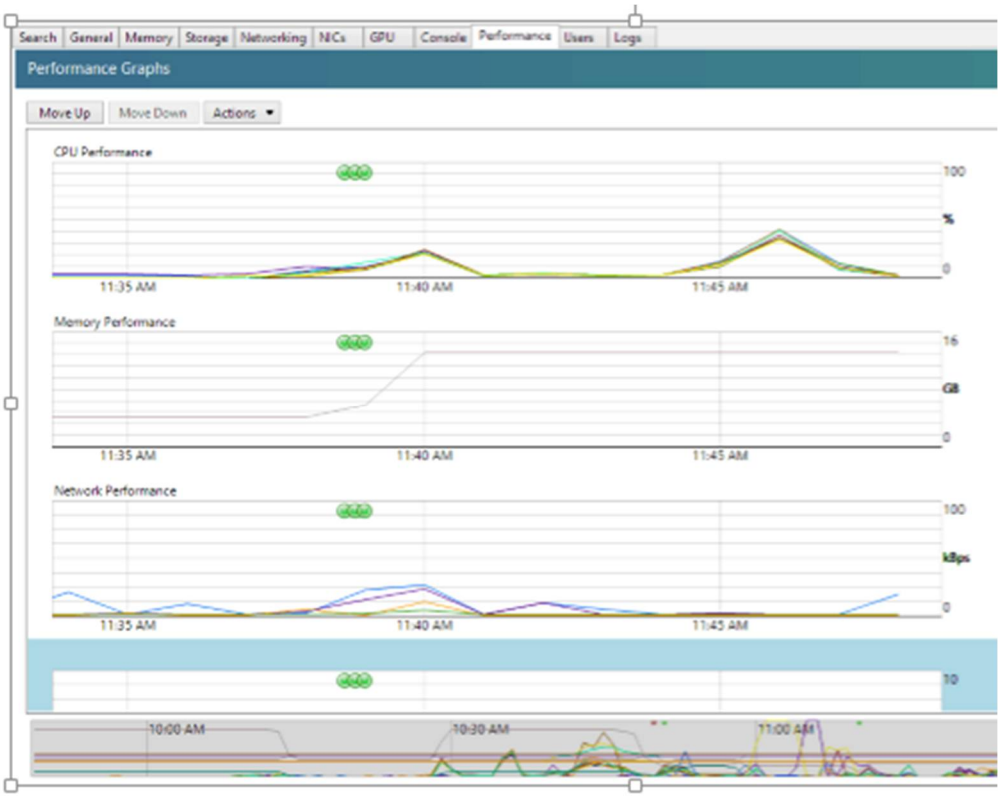

FIGURE 16: PERFORMANCE GRAPH

6. Chapter Six: Conclusion and Recommendation

6.3 Conclusion

This study have presented the current status of ICT usage in Ethiopian small and medium enterprise, limitations of the current ICT service delivery and identification of better ICT service delivery technologies has been studied

The rationale behind this research study was based on the recognized difficulty of setting up complex ICT infrastructure in a traditional computing environment for enhancing the productivity and effectiveness of certain activities or functions made by SMEs due to either financial issues, low infrastructure, legal issues or low IT knowledge. Cloud computing promises to improve the reliability and scalability of IT systems, which allows SMEs to focus their limited resources on their core business and strategy.

Basically, the literature review has been organized in three sections. The first section covers important concepts and characteristics of types of cloud computing. The second section covers the use of cloud computing in SMEs and explains its different types. In the third section, empirical evidence on the subject matter is discussed briefly.

Cloud computing provides a solution to all these issues by offering a wide range of services which can remove technological barriers for SMEs in the involving global market. A Cloud-based framework has been presented which combines the existing open sources to host different services. The proposed framework has been validated by interoperability and scalability comprise all features regarding the maximal number of available resources which can be used simultaneously from the cloud system.

The resulting framework facilitates collaboration between SMEs and assists newcomers into the market. The different components of the proposed framework offer powerful capabilities to address both services and resources management. This will provide enhanced degrees of scalability, flexibility, and simplicity for management and delivery of services in the clouds.

6.4 Recommendation

Although the results of this study are hopeful, further work needs to be done in order to realize the proposed framework to Ethiopian SME. The proposed framework should be implemented on the selected business process and tested so that the proposed framework will be modified based on the feedback before the framework`s full implementation in all SMEs business process.

Some suggestions and future research directions are presented next.

- Developing framework`s for SMEs on enhancing the security architecture of virtual data centers in Cloud Environment for SMEs. Researchers might focus on providing security in the cloud that protects the data in the Cloud Environment.
- Future studies can carry out on exploring business models of cloud computing services for SMEs and their differences according to business model ontology.
- Exploring the critical issues in selecting cloud service providers, cloud-based service delivery model, and cloud computing deployment model (Private & hybrid). In particular, it should be analyzed by describing the strength and weakness from service provider to cloud-based service delivery and deployment model for SMEs more securing their data.
- Adoption and usage issue that were considered in this study can be further studied in depth from multiple dimensions.

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Appendices

Appendix A: Cover Letter for Interviews

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF ELECTRICAL AND COMPUTING

DEPARTMENT OF COMPUTING

INTRODUCTORY LETTER

Dear Respondent

My name is Melese Tezera I am a student in the post graduate program specialization in Degree of masters of Science in Information System in Adama science and Technology University. I am conducting a search on the topic**"** A Cloud Computing Framework for Ethiopian Small and Medium Enterprise"**.** Cloud computing is a new technology concept that delivers IT services as computing utility through the Internet.

The aim of this research is to develop a Cloud Computing Framework that would assist SMEs to use and adopt for cloud-based services. In order to achieve the main objectives of this research and effectively address the research questions, we designed to collect primary data from various sectors of SMEs regarding ICT and related issue.

I would like to require to your kind cooperation to take a few minutes of your precious time to give an answer to the interview questions. Since the data in required for the academic purpose, only any information you share will be kept strictly confidential. Thank you for your willingness to contribute towards on this research.

Thank you for responding to the questions

MELESE TEZERA

ADAMA, ETHIOPIA

Appendix B: Interview Questions

Please briefly explain your expectations about the following question

SECTION A: GENERAL INFORMATION

1. What is the current position that you hold in this enterprise?
2. What enterprise or economic sector does your enterprise belong to?
3. How many staff members are employed in your company/business?

SECTION B: ICT SUPPORT IN YOUR COMPANY

1. How can you are utilized ICT and for what purpose you use it?
2. Do you have challenges when you use ICT for your business?
3. Do you think the current ICT services and supports that are provided are enough to achieve your business goal?

SECTION C: About Cloud Computing Questions

1. Have you try and tested any online IT services for your business which may help you to perform better?
2. What do you understand about cloud computing technology?

Appendix C: Installing XenServer 6.5 and XenCenter 6.5

This section steps through installing XenServer on a single physical host, installing XenCenter on a Windows computer, and connecting them to form the infrastructure for creating and running virtual machines (VMs).To get started, we need at least two separate physical computers:

- XenServer host and
- A desktop computer to run the XenCenter application.

The XenServer host computer is dedicated entirely to the task of running XenServer hosting VMs and is not used for other applications. The computer that runs XenCenter can be any general-purpose Windows computer that satisfies the hardware requirements and can be used to run other applications too.

Install the XenServer 6.5

Steps:

1. Insert the main installation CD into the DVD drive of the host computer.

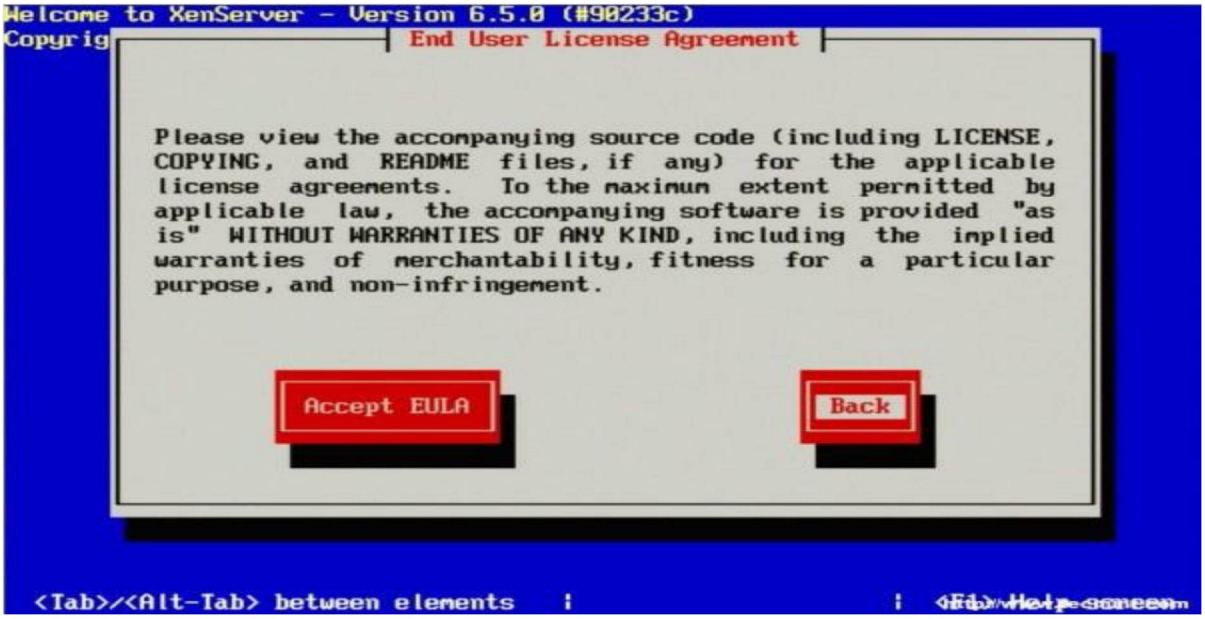
2. Restart the host computer.

3. Boot from the DVD drive (if necessary, see your hardware vendor documentation for information on changing the boot order).

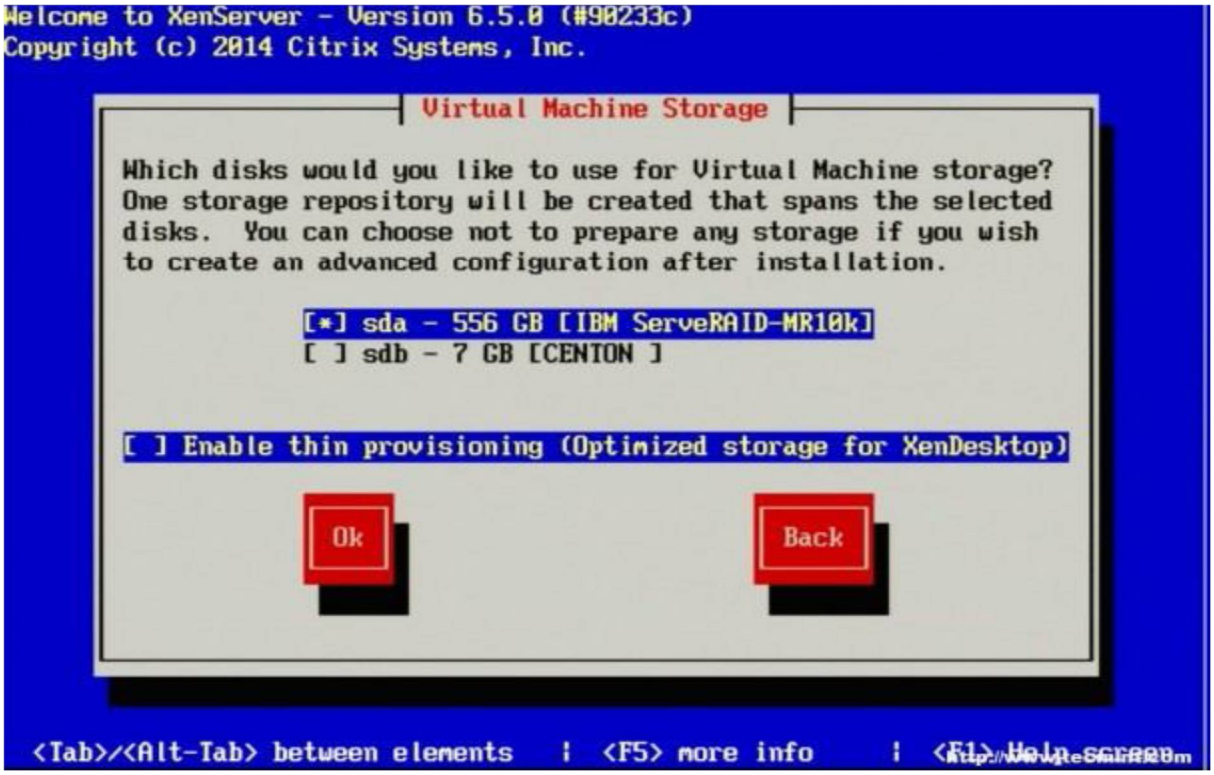
4. Following the initial boot messages and the Welcome to XenServer screen, select your keyboard layout for the installation.

5. When the Welcome to XenServer Setup screen is displayed, select Ok.

6. Read and accept the XenServer End User License Agreement (EULA).



1. If you have multiple hard disks, choose a Primary Disk for the installation. Select Ok. Choose which disk(s) you would like to use for virtual machine storage. Choose Ok.



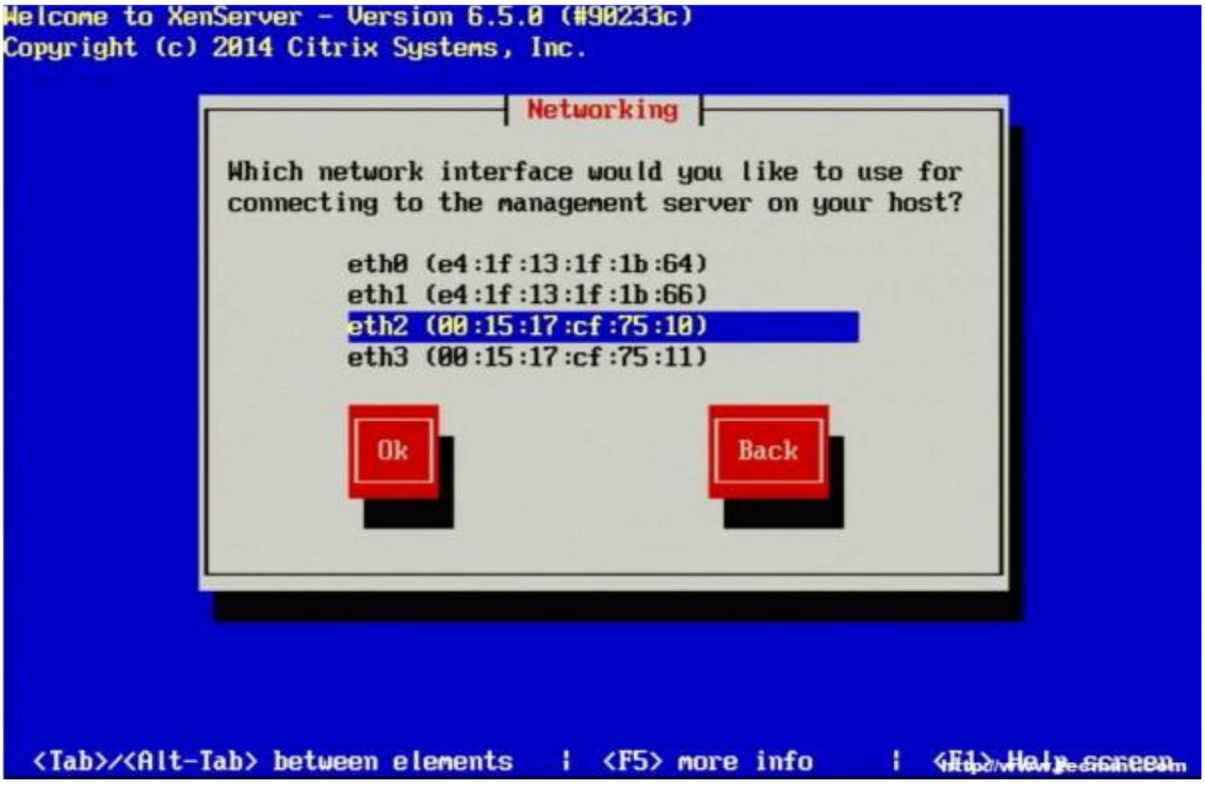
8. Select Local media as your installation source.

9. When prompted about if you would like to install any supplemental packs, choose No to continue.

10. Select Skip Verification, and then choose Ok.

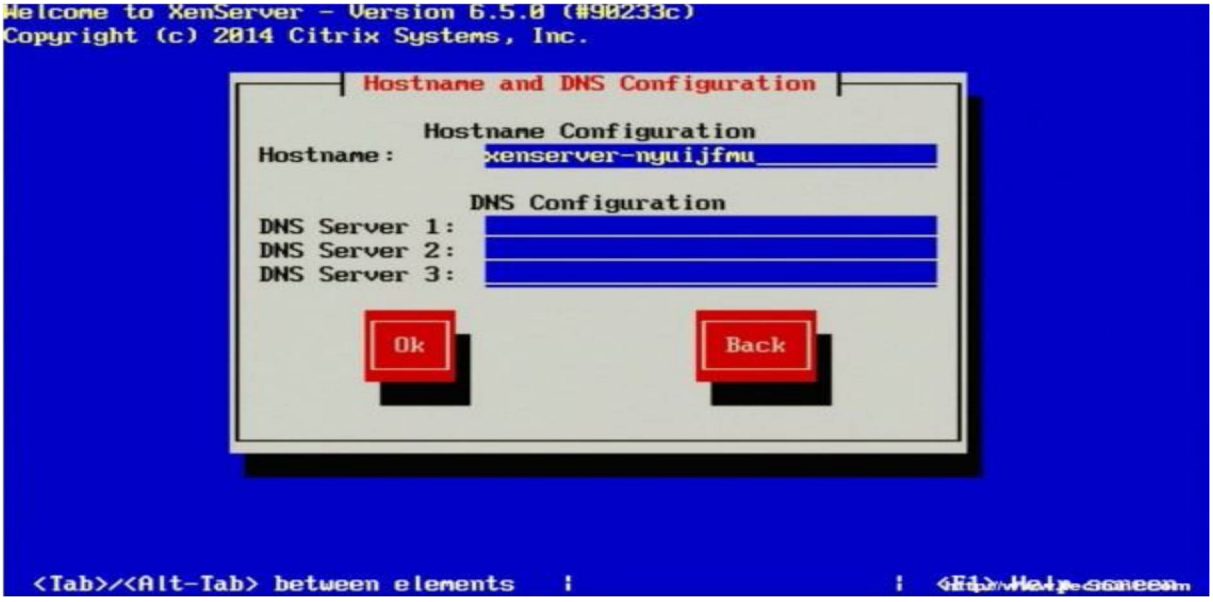
11. Set and confirm a root password, which the XenCenter application will use to connect to the XenServer host.

12. Set up the management interface that will be used to connect to XenCenter.If your computer has multiple network interface cards (NICs), select the NIC which you want to use for management traffic (typically the first NIC). A network port that is not tagged as a VLAN is required for the management interface.



13. Configure the Management NIC IP address with a static IP address or to use DHCP.

14. Specify the hostname and the DNS configuration, manually or automatically via DHCP.If manually configuring the DNS, enter the IP addresses of your primary (required), secondary (optional), and tertiary (optional) DNS servers in the fields provided.



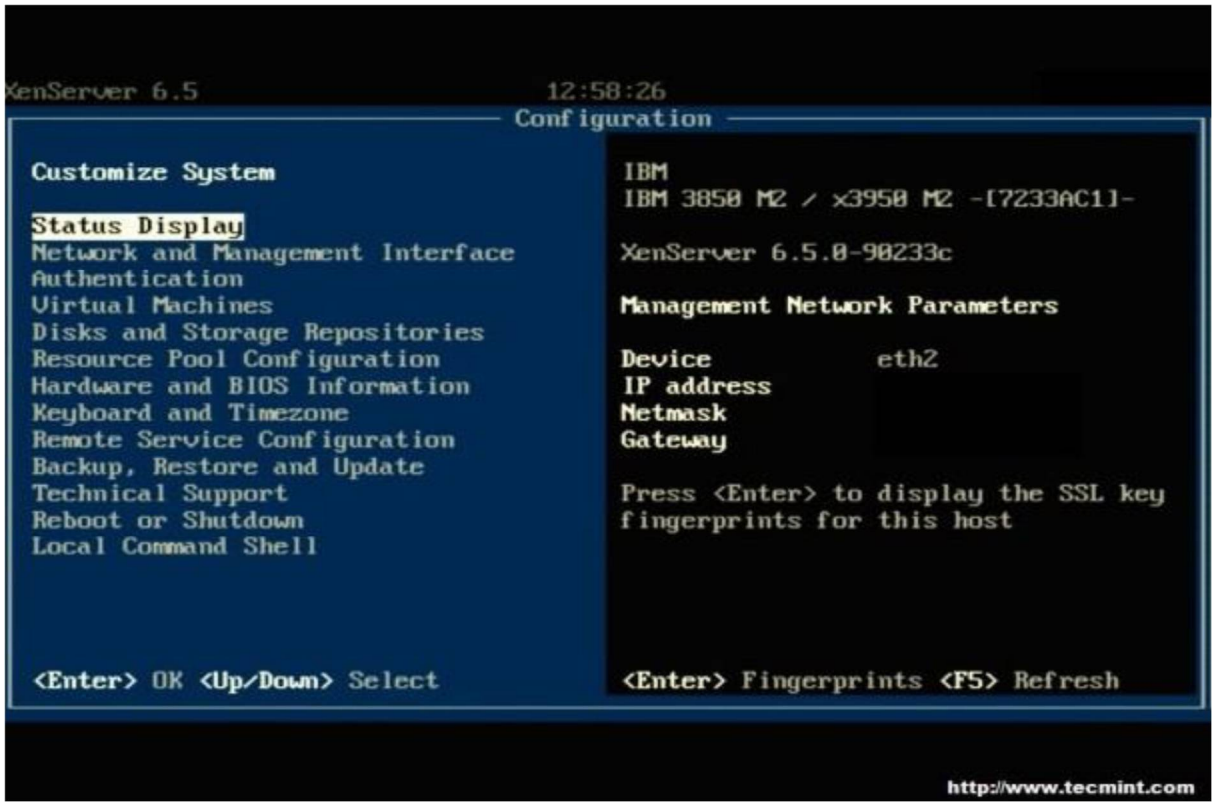
15. Select your time zone — the geographical area and then city.

16. Specify how you would like the server to determine local time: using NTP or manual time entry. Choose Ok.

17. Select Install XenServer.

18. If you elected to set the date and time manually, you are prompted to do so.

19. From the Installation Complete screen, eject the installation CD from the drive, and then select Ok to reboot the server.



Installing XenCenter

The system requirements for XenCenter are local desktop or laptop with Operating System: Windows 7, Windows XP, Windows Vista, Windows Server 2003, Windows Server 2008, Windows Server 2008 R2 (all editions and versions)

.NET Framework: Version 3.5 or greater

CPU Speed: 750 MHz minima, 1 GHz or faster recommended

RAM: 1 GB minimum, 2 GB or more recommended

Disk Space: 100 MB minimum

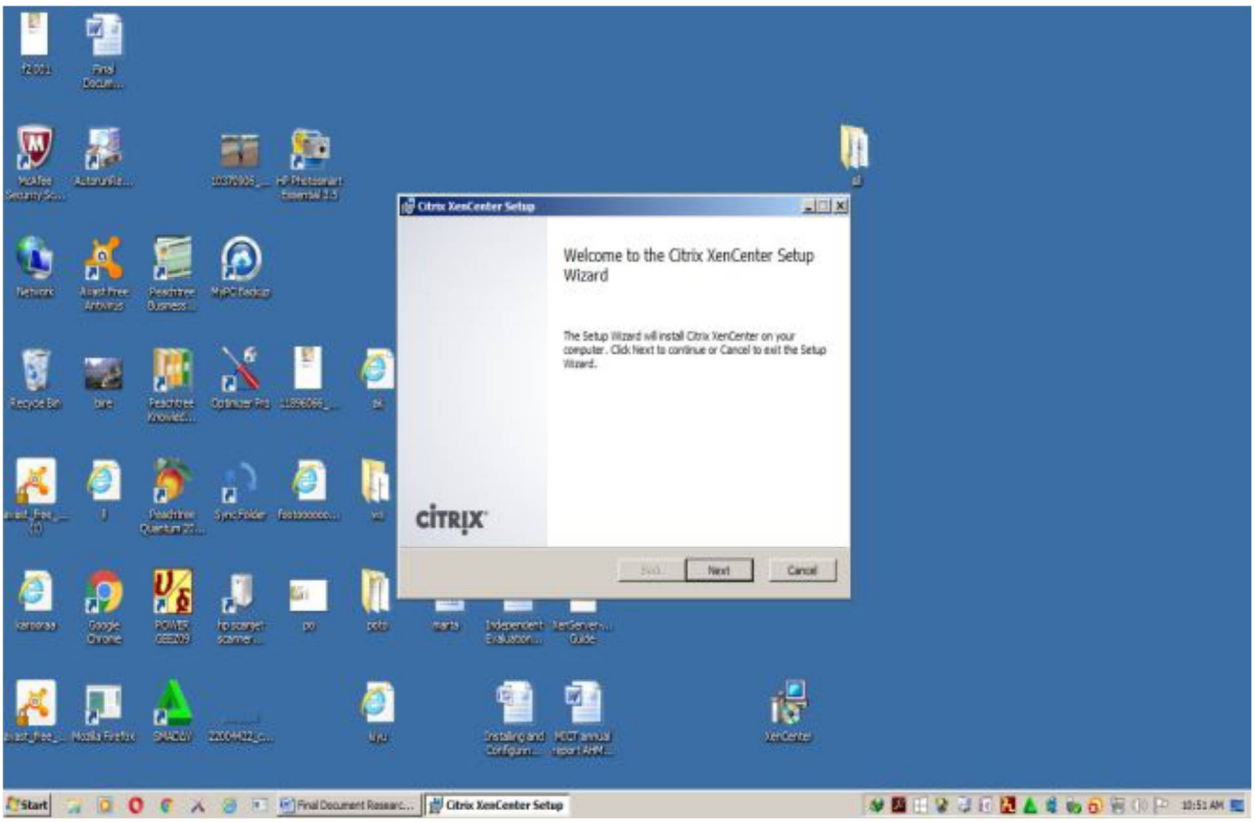
Network: 100Mb or faster NIC

- **Screen Resolution: 1024x768** pixels, minimum.

To install XenCenter;

1. Insert the main installation CD into the DVD drive of the computer which you want to run XenCenter.

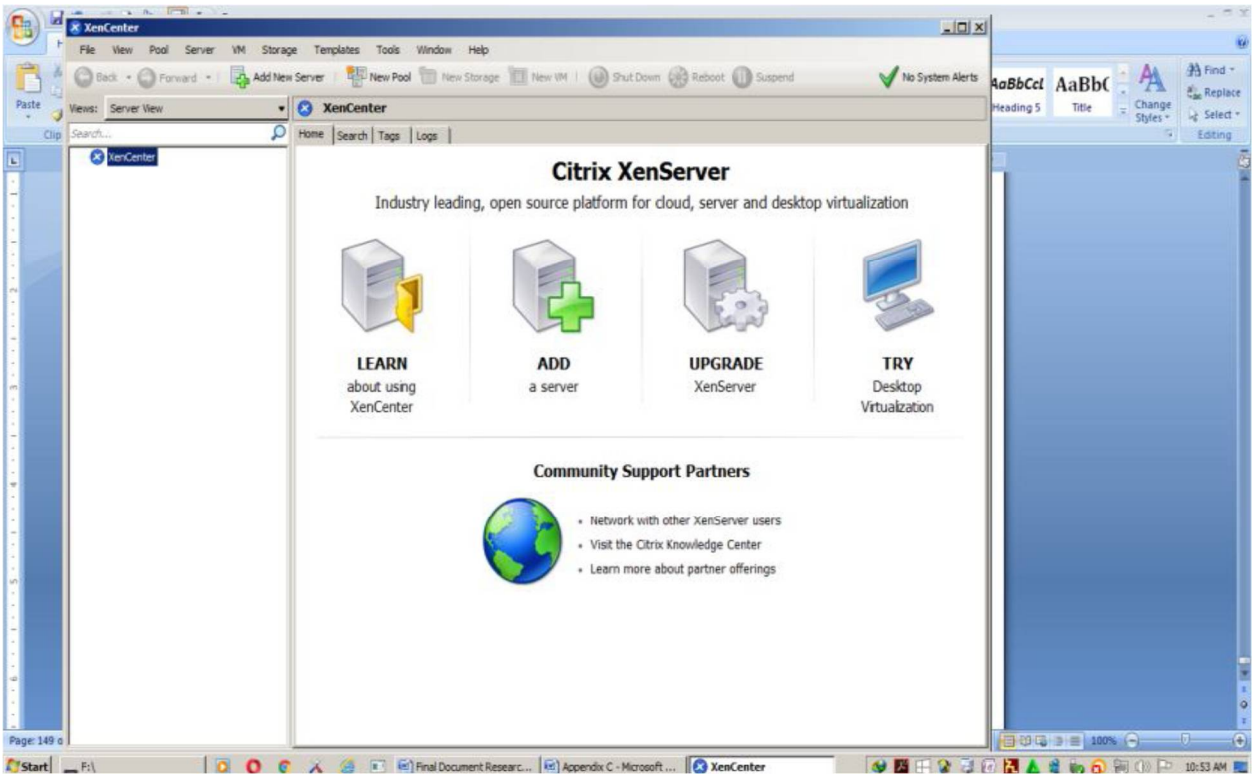
2. Open the client install folder on the CD. Double-click XenCenter.msi to begin the installation.



3. Follow the Setup wizard, which allows you to modify the default destination folder and then to install XenCenter.

4. In the **Server** field, enter the IP address of the host. Enter the root username and password that you set during XenServer installation. Choose **Add**.

5. Finally, the following will be displayed


XenCenter
File View Pool Server VM Storage Templates Tools Window Help
Add New Server
New Pool
New Storage
New VM
Shut Down
Reboot
Suspend
No System Alerts
Views: Server View
XenCenter
Home Search Tags Logs
Citrix XenServer
Industry leading, open source platform for cloud, server and desktop virtualization
LEARN about using XenCenter
ADD a server
UPGRADE XenServer
TRY Desktop Virtualization
Community Support Partners
Network with other XenServer users
Visit the Citrix Knowledge Center
Learn more about partner offerings