
# ADDIS ABABA UNIVERSITY

## COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES

## SCHOOL OF INFORMATION SCIENCE

# A FRAMEWORK OF VIRTUALIZED INFRASTRUCTURE AS A SERVICE FOR ETHIOPIAN BANKING INDUSTRY

By:

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

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Addis Ababa, Ethiopia


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| **……(PhD)** | _____ | _____ |
| **Examiner** | **Signature** | **Date** |

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# Declaration

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

I declare that the thesis is a result of my own investigation, except where otherwise stated. I have undertaken the study independently with the guidance and support of my research advisor. Other sources are acknowledged by citations giving explicit references. A list of references is appended.

Signature: _____

**Tigist Yegremachew**

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

Advisor's Signature: _____

**Workshet Lamenew (PhD)**

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# Table of Contents

## Abstract

The growth of servers within the DCs leads to think better solution to utilize and manage resources effectively. Thus, Virtualization is being used by a growing number of organizations to address these critical situations and become a better solution to consolidate their workloads, to make their IT environments scalable and more flexible.

Virtualization is the foundation of cloud computing and forms the base for offering cloud services. Virtualization technology implementation practices, its use for the banking Industry and how better to take the advantage of virtualization technology, have been done elsewhere, such attempts in developing countries like Ethiopia is lacking. To this end, this thesis tried to assess virtualization technology implementation practices, benefit and challenges with the view to identify improvement aspects and to propose IaaS framework for banking industry.

Design science research methodology is selected so as to design the proposed framework. Observation, Semi-structured interview, and document analysis were the data collection instruments used to gather appropriate data. Based on interview result data was analyzed using Thematic Analysis Technique (TAT) in which the result of interview was grouped in to main categories. Based on the result and related literatures the researcher have proposed and customized Infrastructure as a Service Framework which will be applicable for Ethiopian Banking Industries. A practical demonstration of proposed frame work has been done by using simulation tools and acquired test results were stated.

Based on current state analysis of the business requirements which arise from banking industries a proposed framework targeted to improve effective utilization of resources, reduce cost associated with the information technology infrastructure and to reduce operational complexities in Ethiopian Banking Industries. In order to meet the banking industries requirements this study identifies the key elements necessary to be included in this framework. Based on the current analysis the study focused search for existing knowledge and best practices suitable for Ethiopian Banking industries and key elements in the related framework.



**Keywords**: **Virtualization Technology, Framework of IaaS**

## List of Figures

## List of Tables

## List of Acronyms

The following is a list of acronyms and their meanings used throughout the text

| Acronym | Description |
|---|---|
| APP | Application |
| BOA | Bank of Abyssinia |
| CBE | Commercial Bank of Ethiopia |
| CCTV | Closed Circuit Television |
| CPU | Central Processing Unit |
| CRM | Customer Relationship Management |
| CSP | Customer Service Provider |
| DAS | Direct Attached Storage |
| DC | Datacenter |
| DC's | Datacenters |
| DR | Disaster Recovery |
| DRS | Distributed Resource Scheduler |
| DSRM | Design Science Research Methodology |
| DRS | Distributed Resource Scheduler |
| EBI's | Ethiopia Banking Industries |
| HDD | Hard Disk Driver |
| IaaS | Infrastructure as a Service |
| ICT | Information Communication Technology |
| IEEE | Institute of Electrical and Electronics Engineers |
| IS | Information System |
| IT | Information Technology |
| LAN | Local Area Network |
| NAS | Network Attached Storage |
| NBE | National Bank of Ethiopia |
| NIC | Network Interface Card |
| OS | Operating System |
| PC | Personal Computer |
| PaaS | Platform as a Service |
| QoS | Quality of Service |
| RAID | Redundant Array of Independent Disks |
| SLA | Service Level Agreement |
| SaaS | Software as a Service |
| SAN | Storage Area Network |
| VD | Virtual Disk |
| VHD | Virtual Hard Disk |
| VI | Virtual Infrastructure |
| VLAN | Virtual Local Area Network |
| VN | Virtual Network |

| | |
|---|---|
| VM | Virtual Machine |
| VMM | Virtual Machine Monitor |
| VR | Virtual Resource |
| VS | Virtual Storage |
| VDs | Virtual Distributed Switch |
| VPN | Virtual Private Network |
| VCPU | Virtual Central Processing Unit |
| WAN | Wide Area Network |

# Chapter 1

# Introduction

## 1.1Background

Cloud computing is a recent technology that enables organizations to share various services in a unified and cost-effective manner (Sareen, 2013). Nancy (2016) argues that cloud computing helps for banks to transform their business processes and enhance their ability to grow in new sectors without cost burdens.

Banks use Information Technology Services in order to satisfy customers need and to deliver better services (Meskerem & Abrehet, 2014). For banks cloud computing affects the entire business and Cloud technology offers a new model for delivering innovative client experiences, effective collaboration, improved speed to market and increased IT efficiency (Sheel, Rupali, & Kalpesh, 2014).

The Cloud Service Providers are able to provide IT infrastructures to meet the demand from the cloud users by simply leasing infrastructure. This is achieved by the infrastructure provider using virtualization, where customers of the cloud service share the same physical services that are virtualized logically (Gabriel & Arif, 2015).

Virtualization is the foundation of cloud computing and forms the base for offering cloud services. Therefore, it is very essential for an organization to be aware of the virtualization technology and its benefit (Kedia, Renuka, & Tejinder, 2013). The virtualization of information technology infrastructure creates the enablement of IT resources to be shared and used on several other devices and applications this creates the growth of business needs (Gabriel & Arif, 2015).

The growth of servers within the DCs leads to think better solution to utilize and manage resources effectively. Thus, Virtualization is being used by a growing number of organizations to address these critical situations and become a better solution to consolidate their workloads, to make their IT environments scalable and more flexible (Rakesh & Shilpi, 2015).

Virtualization is not a new technology, but it has regained popularity in recent years because of the potential of improved resource utilization through server consolidation (Udeze, Okafor, H. C, & C. C, 2012; Sari, 2015; Gabriel & Arif, 2015).

Virtualization was first developed in 1960's by IBM Corporation, originally to partition large mainframe computer into several logical instances and to run on single physical mainframe hardware as the host (Benard & David, 2017). It was invented for mainframes to be able to support multiple users running different tasks, isolated from each other in memory (Shrithi & Vanamala, 2014).

The scientist realized that this capability of partitioning allows multiple processes and applications to run at the same time, thus increasing the efficiency of the environment and decreasing the maintenance overhead (Hamdani & Putera, 2016).

Virtual machine has been in existence since 1960s when IBM made the first ever VM to enable repeated interface access to a mainframe computer. Then each VM was an instance of the physical machine and it was a transparent way of enabling time-sharing and resource sharing on expensive hardware. Virtualization is a combination of hardware and software that creates VM and enables multiple operating systems to run on the same physical platform (Rakesh & Shilpi, 2015).

According to Gabriel& Arif (2015) computer that is virtualized, can host more than one operating system in its virtualized environment, running at the same time, and virtual machines can be deployed on any system, and it doesn't rely on the operating system nor hardware of the host. This enables multiple applications or operations to gain access to the hardware and software resources of the host machine.

Virtualizations across Datacenter is a growing technology for banking sector which provides the capability of system to host multiple virtual machines while running on a single hardware platform, effective utilization of resources, reduction of power consumption, reduce information technology cost through server consolidation, standardization and physical space consolidation. It also increases IT service efficiency through centralized administration.

Presently, Virtualization technology implementation is rapidly under way in different sectors and adopting, virtualization technologies in the DCs helps to improve system security, reliability and availability, reduce costs and provide greater flexibility (Radhwan & Asmaa, 2013).

On the other hand Cloud Computing is defined as a pool of virtualized computer resources. Based on this Virtualization technology the Cloud Computing paradigm allows workloads to be deployed and scaled-out quickly through the rapid provisioning of virtual machines or physical machines (Omkar, Shweta, Deepali, & PamuKumar, 2012).

According to Bhardwaj, Leena, & Sandeep (2010) cloud computing is an increasingly popular paradigm for accessing computing resources. In practice, cloud service providers tend to offer services that can be grouped into three categories: SaaS(Software as a Service), PaaS(Platform as a Service), and IaaS(Infrastructure as a Service).

SaaS is the idea that service provider can offer you a hosted set of software running on a platform or system applications and infrastructure, PaaS is the idea that someone can provide the hardware plus a certain amount of application software and IaaS in cloud computing is one of the most significant, fastest growing field and it is the delivery of hardware (server, storage and network) with associated software (operating systems virtualization technology, file system), as a service (Sunilkumar & Gopal, 2014).

In case of SaaS that you don't own but pay for some element of utilization by the user, or some other kind of consumption bases, in PaaS integration into a common set of programming functions or databases as a foundation upon which you can build your application and in the case of IaaS an evolution of traditional hosting that does not require any long term commitment and allows users to provision resources on demand (Sushilj, Leena, & Sandeep, 2010).

Cloud computing is known as on-demand computing and one of the latest developments in the IT industry and it provides the full scalability, reliability, high performance and relatively low cost feasible solution as compared to dedicated infrastructures (Nancy, 2016).

In addition, Virtualization is a fundamental part of cloud computing, especially in delivering IaaS (Krishna, Eswar, Sai, & J.N, 2013). IaaS as the fundamental layer in the cloud service model has gained more attention recently in academic research because of its compatibility with many real-life applications and services.

Therefore, virtualization technology using IaaS help banks to effectively utilize resources in the datacenter by considering shared costs with low investment, to build a standard and modern common DC framework for all organizations and achieve greater agility and increasing IT efficiency through cloud based IaaS services.

## 1.2 Statement of the problem

Datacenter (DC) host diverse and heterogeneous interconnected IT equipment like Storage Devices, Servers, Generators, Air Conditioner, Fire Suppression, CCTV, Access Control and other related infrastructures resources (Mueen & Azizah, 2011).

In case of Banking Industries DC equipment's are supplied from different suppliers. As data increases the need of hardware requirement and different datacenter suppliers also increase in the DC. This leads to maintenance costs of Datacenter equipment's to continue to rise, including the purchase and set up of hardware devices, power and cooling requirements, daily monitoring and maintenance (Shrithi & Vanamala, 2014).

The need of hardware requirement in the DC infrastructures Nowadays for EBI's brings also some challenges. This are each banks need to assign a dedicated person for each administration of their infrastructure, focus on their infrastructure than profit maximizing tasks and administration problem for capable competent person may not available for all banks.

Efficient virtualization technology constitutes the core of DC implementation and help efficient resource management. However, managing diverse and heterogeneous datacenter resources, As the number of datacenters increases the complexity of the resource allocation and management increases, managing multiple datacenter equipment's and resources adds more management

challenges and handling scalability issues is one of the main challenges in the banking industries nowdays.

In addition organizations are investing huge capital for building DC for production and disaster recovery. But, investing huge capital is not mandatory for enterprises. According to, Saleem (2011) enterprises save their capital by not building their datacenter and not hiring employees for managing them.

Along with that flexibility and different pricing models make Cloud Computing more cost effective for enterprises. The service provider supplies the hardware and software necessary for the service, there is no need for a company to provision or deploy its own resources or allocate IT staff to manage the service (Goyal, 2013).

However, in EBI's there is huge cost investment on each bank for their infrastructure for building a production and disaster recovery in order to the data of banking industries to be duplicated.

Resource management framework of IaaS in cloud computing offers the following benefits: scalability, quality of service, optimal utility, reduced overheads, improved throughput, reduced latency, specialized environment, cost effectiveness and simplified interface (Sunilkumar & Gopal, 2014). This might reduce infrastructure investment cost and its management complexities to banks.

To the best of the researcher there was no research conducted for banking industries in Ethiopia to fill the gaps listed in the above Points. Thus, based on the identification of gaps in the literature and prior studies recommendations this study attempts to answer the following research questions

1. Is Implementation of virtualization technology a worthwhile investment in the EBI?
2. Could IaaS framework be an alternative solution for effective utilization of resource for EBI?

## 1.3 Objective

### 1.3.1 General Objectives

The main objective of this study was to propose IaaS framework for banking industry through assessment of current virtualization technology implementation practices, benefit and challenges of virtualization technology with the view to identify improvement aspects and to achieve the best possible solution for virtualized DCs.

### 1.3.2 Specific Objectives

The specific aims of the study are:

1. To identify advantages associated with the implementation of virtualization technology in EBI
2. To identify challenges associated with the implementation of virtualization technology in EBI
3. To Identify technical improvements aspects of virtualization technologies implementation practices in EBI
4. To propose and design Virtualized IaaS framework For EBI
5. To evaluate the proposed designed framework

## 1.4 Significance of the study

This research helps for Ethiopian Banking Industries to consider alternative ways to reduce ICT budgets for infrastructure investment, to effectively manage resources placed in different heterogeneous environments, to promote centralization of hardware resources, to build a DC which is standard for all EBIs and helps for effective infrastructure deployment strategy.

This study also gives insights for other institutions especially organizations looking to adopt virtualized IaaS services. Additionally, this study helps for local Infrastructure provider how to implement effective utilization of infrastructure resources using virtualization technology and how to deliver virtual services for customers. The proposed private IaaS cloud computing model and implementation plan of proposed framework could also be used as a baseline for the newly emerged ICT utilization strategy used in banking institutions.

## 1.5 Scope of the study

This study was limited to IaaS framework for Ethiopian Banking Industries. The study was intended to examine virtualization technology implementation practices, benefit and challenges of virtualization technology with the view to identify improvement aspects and to achieve the best possible solution for virtualized IaaS framework for banking industries and validate the proposed framework using practical demonstration of the proposed framework.

## 1.6 Organization of the thesis

**Chapter 1:** This chapter discusses about background information about cloud computing, virtualization technology, research problems with the objective of the research, the scope of the study with research motivation. It also justifies the significance of the research.

**Chapter 2:**This chapter covered related on the basic concepts of datacenter, virtualization concepts and architecture, components of virtualization ,types of virtualization, benefit and challenges of virtualization, various virtualization products and technologies ,properties of virtualization, virtualization and cloud computing, benefit of computing, architectural layer of cloud computing ,cloud service models, cloud computing advantage for, characteristics and components of IaaS, Infrastructure Service Model for banks and related works done related to study locally and abroad in order to implement in the banking sector.

**Chapter 3**: The main aim of this chapter is to describe the research methodology and strategy that aim to identify better solution to answer the main research questions that could be provided

to banking industries. It begins by describing design science research methodology, primary data collection and analysis techniques were described as information acquisition method and qualitative type of validity and reliability requirements also described.

**Chapter 4:** Presents the result of the interview described in chapter three. The data collection method utilized was semi structured interview that provided both control and direction through a list of question under interview.

**Chapter 5:** Contains information about the proposed IaaS framework for EBI.It contains the proposed IaaS framework architecture, detail elements of the proposed IaaS framework and its advantage in detail. It also contains the implementation of practical demonstration for the proposed IaaS framework.

**Chapter 6:** Conclusion about the research and recommendations for future research direction is presented

# Chapter 2

# Literature Review

## 2.1 Overview

This chapter reviews the different literatures that are related to the objective of the study discussed. Literatures covered in this chapter are the basic concepts of virtualization, architectures, types, benefit, challenges, properties and various kinds of Products& Technologies.

Inaddtion to the concepts of virtualization the basic concepts of cloud computing, benefits, architectural layers, advantage, Virtualization and Cloud Computing, Characteristics and related works done locally and abroad in order to understand how it is implemented or used in banking sector is discussed.

## 2.2 Introduction to Datacenter

Mueen& Azizah (2011) defined Datacenters (DCs) is a centralized repository for storage, management, networking and dissemination of data and a key part of the infrastructure upon which a variety of information technology services are built.

On the other hand DC is a dedicated facility where computing systems and networking, data storage and other associated equipment are physically located, maintained and operated (Udeze, Okafor, H. C, & C. C, 2012).

DCs has hardware and software components .The hardware components of DCs are firewalls, Intrusion Detection Systems, access switches and core switches and the software components are IPSec, VPN, antivirus software, network management systems and access control server.

## 2.3 Virtualization Concepts and Architecture

### 2.3.1 Virtualization overview

The main idea of virtualization is to provide computing resources as pools. Depending on the needs, resources are then assigned to different applications either manually or dynamically from different pools. The scope of virtualization can vary from a single device to a large datacenter and virtualization can be applied to different areas such as servers, networks, storage and applications.

### 2.3.2 Definition of virtualization

According to Malhotra, Agarwal, & Jaiswal (2014) virtualization is essentially making a virtual picture or form of something, such as server, operating system, storage devices or network resources that can be used on multiple machines at the same time.

On the other hand virtualization is "A framework or methodology of dividing the resources of computer hardware into multiple execution environments, by applying one or more concepts or technologies such as hardware and software partitioning, time-sharing, partial or complete machine simulation, emulation, quality of service and many others " (Rabi, Manas, & Suresh, 2011).

Gabriel & Arif (2015) argue that virtualization is a layer between the hardware and the operating system and it allows multiple applications or operations to gain access to the hardware resources/software resources of the host machine.

Virtualization is run multiple operating systems and applications on a single server, consolidate hardware to get vastly higher productivity from fewer servers and simplify the management, maintenance, and the deployment of new applications (Anu, Meena, & khushwant, 2015).

### 2.3.3Architectures of Virtualization

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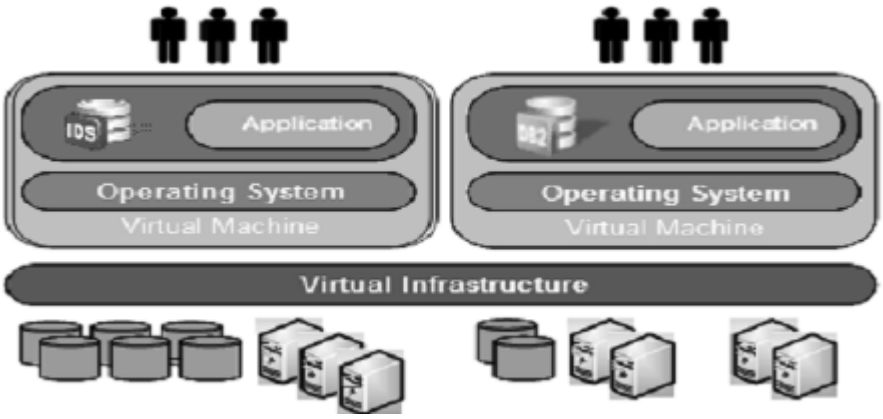


Figure 2.1 Concepts of virtualization (Anu, Meena, & khushwant, 2015)

## 2.4 Components of virtualization

According to Rabi, Manas, & Suresh (2011) there are three components of virtualization Guest OS, Hypervisor or Virtual Machine Manager and Host OS.

### 2.4.1 Guest OS

According to Rabi, Manas, & Suresh (2011) a guest OS is any operating system that runs independently of dedicated hardware resources and it runs in a virtual environment and uses hardware resources allocated dynamically through a hypervisor.

### 2.4.2Hypervisor or virtual machine manager

Virtual Machine Monitor or hypervisor is the foundation of virtualization solutions. It allows multiple VMs to run on a single host to better utilize its hardware resources. The task of hypervisor is to handle resource and memory allocation for the virtual machines, ensuring they

cannot disrupt each other. Hypervisor abstracts the physical layer and presents this abstraction for virtual machines to use (Rakesh & Shilpi, 2015).

### 2.4.3Host OS

According to Rabi, Manas, & Suresh (2011) a host OS is an operating system that accesses the physical machine‘s resources, such as its physical memory and processor speed, and allocates those resources to virtual OS's as needed. A host OS is the first OS installed on a machine to enable a machine to support multiple virtual operating systems.

## 2.5 Types of Hypervisor

There are two types of hypervisor bare Metal hypervisor and hosted hypervisor (Khajehei, 2014; Gabriel & Arif, 2015; Durairaj & Kannan, 2014).

### 2.5.1 Type-1 or Bare-Metal Virtualization

According to Gabriel& Arif(2015)bare-metal hypervisor directly run above the hardware of the host machine. It also monitors the operating system that runs directly above the hypervisor that runs on the guest machine.

Bare Metal Virtualization is fully responsible for scheduling and allocating of systems resources between virtual machines (S & M, 2014).It is more secure than Type II virtualization.

Example: VMware ESX (Enterprise), Xen (Omkar, Shweta, Deepali, & PamuKumar, 2012).

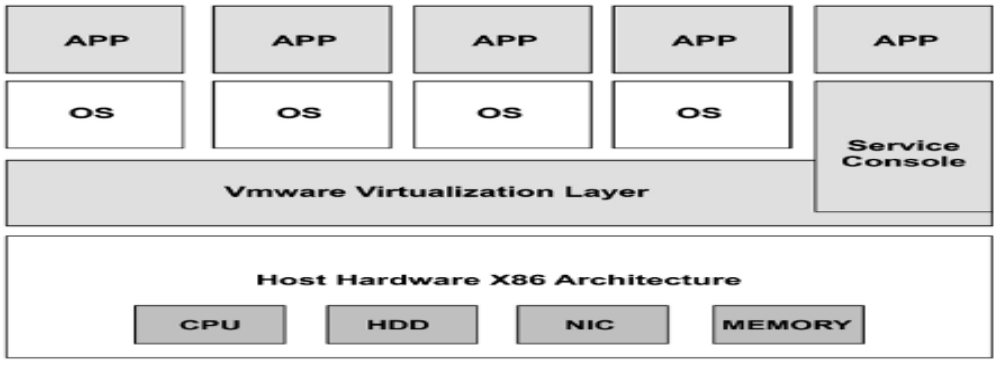


Figure 2.2.Native or bare metal hypervisor (Gabriel & Arif, 2015)

### 2.5.2 Type-2 or Hosted Virtualization

This type of hypervisor allows the hypervisor is hosted or installed on an already on an already existing operating system and it houses other operating system that is above it (Gabriel & Arif, 2015).This type of hypervisor allows for hosting various applications and Operating systems locally or remotely (Durairaj & Kannan, 2014).

In this type of hypervisor according to Gabriel & Arif (2015) any problem occurring with the host operating system will affect guest machine operating system that is running on the hypervisor and may affect the hypervisor itself.

The host Os has no knowledge of the type II VMM which is treated like any other process in the system as we can see figure 2.3. The OS that runs inside of the Type II VMM is referred to as the Guest OS. In this type of hypervisor the OS controls the real hardware resources called Host OS.

According to Omkar, Shweta, Deepali, & PamuKumar (2012) this type of hypervisor Less secure then Type 1 because any security Vulnerabilities that lead to the compromise of the host OS will also give full control of the guest OS.

Examples of such are Oracle VM Virtual Box, VM Ware Server and Workstation, Microsoft Virtual PC, KVM, QEMU and Parallels (Gabriel & Arif, 2015).

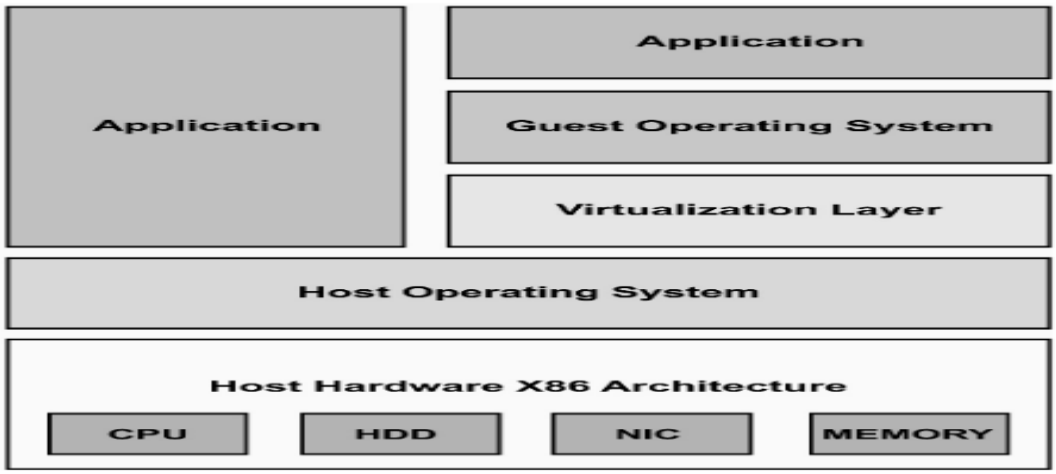

Figure 2.3.Hosted Hypervisor (Gabriel & Arif, 2015)

## 2.6 Types of virtualization

### 2.6.1 Server Virtualization

Server virtualization is a form of hardware virtualization in which a single physical server performs the task of multiple servers by portioning out the resources of an individual server across multi-environment (Durairaj & Kannan, 2014; Pooja, Renuka, & Singh, 2013).

According to Rabi, Manas, & Suresh(2011) advantage of server virtualization

- Reduce Operational Costs ( Hardware ,Energy ,Space)
- Improve uptime and availability
- Enable robust Disaster Recovery
- Reduce Maintenance disruption
- Streamline resource provisioning and scale

### 2.6.2 Storage Virtualization

Storage virtualization is the technique of logically grouping of physical disks and presents those groupings as a virtual disk to the OS (O, Tapas, & Venkateswara, 2017).

Virtualization technology use a technique called RAID to merge physical storage from many devices which will appear as a single storage pool and technique of completely extracting the logical storage from physical storage and scattering it over a network (Pooja, Renuka, & Tejinder, 2013).

Since we only use what is needed storage virtualization brings so reduces the cost of storage, easier to manage tasks as backup, archiving or recovery (O, Tapas, & Venkateswara, 2017).

Storage can be classified as direct attached storage (DAS), network attached storage (NAS) and storage area network (SAN). Storage virtualization is a form of resource virtualization and it is commonly used in SAN (Pooja, Renuka, & Tejinder, 2013; Durairaj & Kannan, 2014).

### 2.6.3 Network Virtualization

Network virtualization is the process of combining hardware and software resources into a virtual network as a single collection of resources. It helps for better infrastructure utilization in terms of reusing a logical or physical resource for multiple other network resources such as hosts, virtual machines, routers and also reducing cost by sharing network resources (Pooja, Renuka, & Tejinder, 2013).

Network virtualizations are (O, Tapas, & Vedula, 2017)

- VLAN: It is a safe method of creating independent or isolate logical networks within a shared physical network. According to the standard of IEEE802.1Q defined a method of creating independent networks using a shared physical network.
- VIP: A VIP is an IP address that is not associated to a specific computer or network interface, but is normally assigned to a network device that is in-path of the network traffic. VIP for High Availability and Load-Balancing, where multiple systems have a common application, and they are able to receive the traffic as redirected by the network device.

### 2.6.4 Desktop virtualization

According to Rabi, Manas, & Suresh (2011) desktop virtualization is creating a separate OS environment over and above the existing running OS on the Desktop.

## 2.7 Benefits of virtualization

Virtualization offers several key benefits:

- ✓ Virtualization allows for maximizing of hardware through sharing of resources, offers improved resource utilization, easy mechanism to cleanly partition physical resources, allowing multiple applications to run in isolation on a single server, helps server consolidation and provides flexible resource management mechanisms (Saraiya, et al.,

2007; Sahoo, J; Mohapatra, S; Lath, R, 2010; Udeze, Okafor, H. C, & C. C, 2012; Johnston & Ogunyemi, 2017).

- ✓ Application portability is improved, without requiring additional development efforts a virtualized environment is easier to backup and restore for disaster recovery purposes (Saraiya, et al., 2007; Scroggins, 2013).
- ✓ Virtualization enables to improve load balancing and fault tolerance (Saraiya, et al., 2007).
- ✓ Security attack on one virtual machine does not compromise the others because of their isolation (Rabi, Manas, & Suresh, 2011)
- ✓ Cost reductions, operations in terms of personnel, floor space and software licenses Operating consumption is reduced including server power consumption or rack space consumption and power consumption of machine rooms' air-conditionings, reliability (Gabriel & Arif, 2015; Omkar, Shweta, Deepali, & PamuKumar, 2012; Shrith & Vanamala, 2014; Rabi, Manas, & Suresh, 2011).
- ✓ Adaptability to Workload Variations: Changes in work load intensity levels can be easily taken care of by shifting resources and priority allocations among virtual machines. (Omkar, Shweta, Deepali, & PamuKumar, 2012).
- ✓ Load Balancing: Since the software state of an entire virtual machine is completely encapsulated by the VMM, it is relatively easy to migrate virtual machines to other platforms in order to improve performance thought better load balancing (Omkar, Shweta, Deepali, & PamuKumar, 2012)
- ✓ Legacy Applications: Even if an organization decides to migrate to a different operating system, it is possible to continue to run legacy applications on the old OS running as a guest OS with in a VM. This reduces the migration cost (Omkar, Shweta, Deepali, & PamuKumar, 2012).
- ✓ Sustainability: Virtualized environments use less environmental resources. Energy consumption in data center is often wasted on machines that are consistently underutilized. Since virtualization allows for many virtual machines to run on one physical machine, less energy is needed to power and cool devices (Omkar, Shweta, Deepali, & PamuKumar, 2012)

- ✓ Responsiveness: Since the virtual environment has the ability to provision itself to get the best out of available resources, response times are faster and downtimes can be reduced to near zero, improving agility and performance (Omkar, Shweta, Deepali, & PamuKumar, 2012)
- ✓ To reduce the number of servers, usage of power and cooling (Scroggins, 2013).
- ✓ Reducing downtime. Virtualization platform supports dynamic migration of virtual servers whether server is damaged or down for maintenance, virtual server can be dynamically moved to safeguard the continuity of the application (Shrithi & Vanamala, 2014).

## 2.8 Challenges of virtualization

According to Radhwan& Asmaa (2013) improper employment of server virtualization can result the following pitfalls

- ✓ Overloading the server utilization infrastructure which can introduce application latency.
- ✓ Increasing IT operational costs because of additional, time and resources required for extensive research efforts.
- ✓ Magnifying failures because a hardware failure could impact multiple virtual servers and the applications they host
- ✓ Introducing virtual machine sprawl, which may substantially increase the overall number of server operating images that need to be managed by system administrators
- ✓ Enabling improper security processes because within the virtual server, the server administrator with access the root ID can alter or disable security settings; thereby , exposing servers to security vulnerabilities
- ✓ Exposing IT operations to network (traffic) uncertainties requiring enhanced IT skill sets to manage more environments at once

## 2.9 Various Virtualization Products & Technologies

Various virtualization products & technologies are (Omkar, Shweta, Deepali, & PamuKumar, 2012; Rabi, Manas, & Suresh, 2011).

a. VMware ( GSX, ESX, VMware workstation )

b. Microsoft (Virtual PC, Virtual server, Hyper-v)

c. Open VZ (Open source container-based virtualization on Linux )

d. Sun (Solaris 10 containers)

e. HP ( vPars, nPartions, IVM's )

f. IBM (PowerVM Virtualization )

g. Virtual Box (It‘sa open source)

## 2.10 Properties of Virtualization

According to Sareen, P. (2013) virtualization has three characteristics that make it ideal for cloud computing:

**2.10.1 Partitioning:** Many applications and operating systems are supported in a single physical system by partitioning (separating) the available resources.

**2.10.2 Isolation:** Each virtual machine is isolated from its host physical system and other virtualized machines. Because of this isolation, if one virtual-instance crashes, it doesn’t affect the other virtual machines. In addition, data isn’t shared between one virtual container and another.

**2.10.3 Encapsulation:** A virtual machine can be represented (and even stored) as a single file, so you can identify it easily based on the service it provides. In essence, the encapsulated process could be a business service. This encapsulated virtual machine can be presented to an application as a complete entity. Therefore, encapsulation can protect each application so that it doesn’t interfere with another application.

## 2.11 Virtualization and Cloud Computing

Cloud computing is one of the most useful technologies that have been widely used all over the world and generally providing on demand IT services and products (Malhotra, Agarwal, & Jaiswal, 2014).

According to Sareen, P. (2013) cloud computing is a term used to describe both a platform and type of application and a cloud computing platform dynamically provisions, configures, and reconfigures servers as needed. Advanced clouds typically include other computing resources such as SAN, network equipment, firewall and other security devices.

Cloud computing offers variety of opportunities that help the organizations to improve their business and use Technology more efficiently (Colin & Felicia, 2016).The central part of cloud computing is virtualization which enables industry or academic IT resources through on-demand allocation dynamically (Durairaj & Kannan, 2014).

Virtualization plays a major role in cloud computing as it provides a virtual storage and computing services to the cloud clients which is only possible through virtualization (Malhotra, Agarwal, & Jaiswal, 2014).

Virtualization forms the foundation of cloud computing, as it provides the capability of pooling computing resources from clusters of servers and dynamically assigning or reassigning virtual resources to applications on-demand (Omkar, Shweta, Deepali, & PamuKumar, 2012).

## 2.12 Benefits of Cloud Computing

Cloud computing offers the following advantages (Bogdan, Madalina, & Ioan, 2015)

- ✓ Lower costs: All resources, including expensive networking equipment, servers, IT personnel, are shared, resulting in reduced costs.
- ✓ Shifting Capital Expenses to Operational Expenses: Cloud computing enables companies to shift money from capital expenses to operating expenses, which ultimately allows the enterprise to focus their money and resources on innovation.
- ✓ Agility: Provisioning on demand enables faster setup on an as needed basis. When a project is funded, customer can initiate service, and then if the project is over, they can simply terminate the cloud contract.

- ✓ Scalability: Many cloud services can smoothly and efficiently scale to handle the growing nature of the business with a more cost effective pay-as-you-go model. This is also known as elasticity
- ✓ Simplified maintenance: Patches and upgrades are rapidly deployed across the shared infrastructure, as well as the backups.
- ✓ Diverse platform support: Many cloud computing services offer built-in support for a rich collection of client platforms including browsers, mobile, and more. This diverse platform support enables applications to reach a broader category of users.
- ✓ Faster development: Cloud computing platforms provide many of the core services that, under traditional development models, would normally be built in house. These services, plus templates and other tools can significantly accelerate the development cycle
- ✓ Large scale prototyping: Cloud computing makes large scale prototyping and load testing much easier. A client can easily spawn 1,000 servers in the cloud to load test your application and then release them as soon as they are done, and then try doing that with owned or corporate servers.

## 2.13 Architectural layers of Cloud Computing

Cloud computing is typically divided into three levels of service Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a service (IaaS) (Samer & V., 2017; Colin & Felicia, 2016; Kuyoro, Ibikunle, & Awodele, 2011).

### 2.13.1 Software as a Service

SaaS is the capability provided to the consumer is to use the provider's applications running on a cloud Infrastructure (Ratan & Anant, 2012).This is the idea that someone can offer you a hosted set of software (running on a platform and infrastructure) that you don't own but pay for some element of utilization by the user, or some other kind of consumption basis (Sushil, Leena, & Sandeep, 2010).

### 2.13.2 Platform as a Service

This is the idea that someone can provide the hardware (as in IaaS) plus a certain amount of application software. It facilitates development and deployment of applications without the cost and complexity of buying and managing the underlying infrastructure, providing all of the facilities required to Support the complete life cycle of building and delivering web applications and services entirely Available from the Internet. This platform consists of infrastructure software, and typically includes a database, middleware and development tools (Sushil, Leena, & Sandeep, 2010).

### 2.13.3 Infrastructure as a Service

The main concept of Infrastructure as a Service (IaaS) is virtualization (Colin & Felicia, 2016). IaaS is the delivery of hardware (server, storage and network), and associated software (operating systems virtualization technology, file system), as a service (Bhardwaj, Leena, & Sandeep, 2010) as shown in Figure 2.4 IaaS,PaaS and SaaS

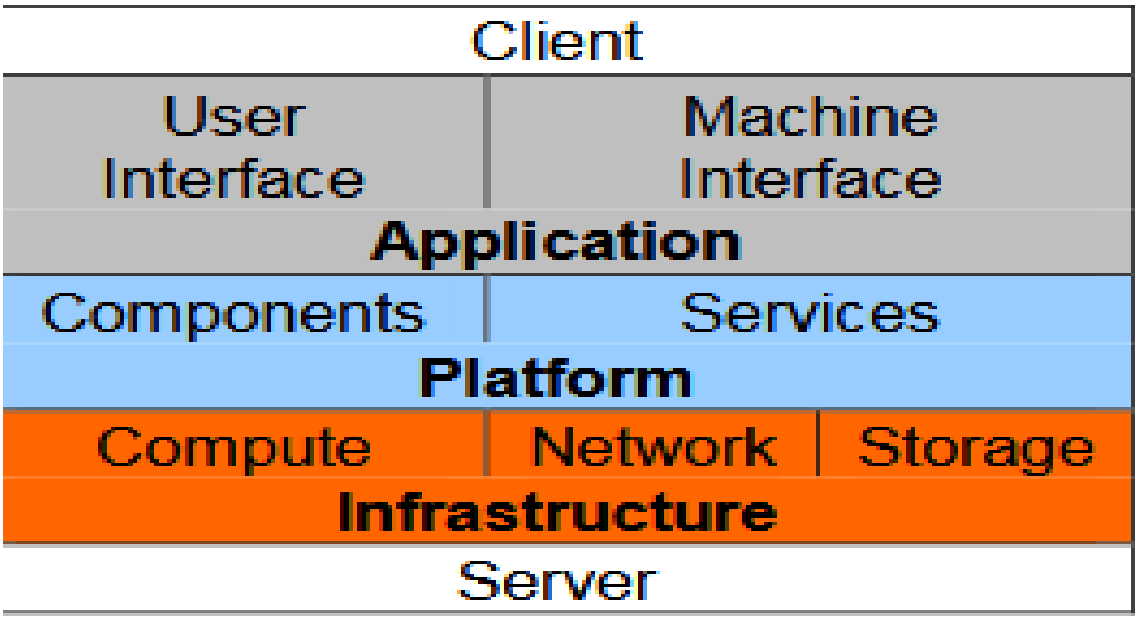


Figure 2.4 Cloud Computing Stack (Sushil, Leena, & Sandeep, 2010)

## 2.14 Cloud Computing Advantage for Banks

According to Sheel, Rupali, & Kalpesh (2014) cloud computing offer financial institutions a number of advantages

### 2.14.1 Cost Savings and Usage- based Billing

With cloud computing, financial institutions can turn a large up-front capital expenditure into a smaller, ongoing operational cost. There is no need for heavy investments in new hardware and software. In addition, the unique nature of cloud computing allows financial institutions to pick and choose the services required on a pay-as-you-.go basis

### 2.14.2 Business Continuity

With cloud computing, the provider is responsible for managing the technology. Financial firms can gain a higher level of data protection, fault tolerance, and disaster recovery. Cloud computing also provides a high level of redundancy and back-up at lower price than traditional managed solutions.

### 2.14.3 Business Agility and Focus

The flexibility of cloud-based operating models lets financial institutions experience shorter development cycles for new products. This supports a faster and more efficient response to the needs of banking customers. Since the cloud is available on-demand, less infrastructure investments are required, saving initial set-up time.

Cloud computing also allows new product development to move forward without capital investment. Cloud computing also allows businesses to move non-critical services to the cloud, including software patches, maintenance, and other computing issues. As a result, firms can focus more on the business of financial services, not IT.

### 2.14.4 Green IT

Organizations can use cloud computing to transfer their services to a virtual environment that reduces the energy consumption and carbon footprint that comes from setting up a physical infrastructure leads to more efficient utilization of computing power and less idle time.

## 2.15 Cloud Computing Security Issues

This is the major threats which hinder the usage of cloud computing services Abusive use of Cloud Computing, Insecure interface and API, Shared Technology issues or Multi-tenancy Vulnerabilities, Data Loss and Leakage and identity theft (Kashif & Sellapan, 2013).

There are 4 types of cloud computing security issues these are Privacy, Security, Reliability and open standard (P. R. & A. W., 2014).

A. **Privacy:** Cloud computing utilizes virtual computing technology. So there might be few chances that un-legitimate user may leak hidden information, which in turns compromises privacy of data.
B. **Security:** Some argue that customer data is more secure when managed internally, while others argue that cloud providers have a strong incentive to maintain trust and as such employ a higher level of security. However, in the cloud, your data will be distributed over these individual computers regardless of where your base repository of data is ultimately stored. Industrious hackers can invade virtually any server, and there are the statistics that show that one-third of breaches result from stolen or lost laptops and other devices and from employees' accidentally exposing data on the Internet, with nearly 16 percent due to insider theft.
C. **Reliability:** The cloud servers also experience downtimes and slowdowns, what the difference is that users have a higher dependent on cloud service provider (CSP) in the model of cloud computing. There is a big difference in the CSP's service model, once you select a particular CSP, you may be locked-in, thus bring a potential business secure risk.
D. **Open Standard**: In cloud computing, open standards are critical to grow. Many CSP provides well documented APIs which are unique to their implementation and thus difficult to interoperable. Towards the progress, there are many open standards are under development; OGF's Open Cloud Computing Interface is one of them. The Open Cloud

Consortium (OCC) is working to develop consensus on early cloud computing standards and practices.

## 2.16 Infrastructure as a Service Model

IaaS is a capability to provision processing, storage, networks, and other computing resources, where an organization can deploy and run arbitrary software such as operating systems and applications.

Some of the key concepts of IaaS include:

- Cloud bursting: The process of off-loading tasks to the cloud during times when the most compute resources are needed
- Multi-tenant computing:- a concept that refers to an infrastructure shared by several organizations with similar interests in regard to security requirements and compliance considerations.
- The hypervisor:- A hypervisor or VMM is computer software, firmware or hardware that creates and runs virtual machines
- Resource pooling:- IaaS software is low-level code that runs independent of an operating system—called a hypervisor—and is responsible for taking inventory of hardware resources and allocating said resources based on demand .This process is referred to as resource pooling.

## 2.17 Characteristics and components of IaaS

According to Sushil, Leena & Sandeep(2010) the main characteristics and components of IaaS model is

- ✓ Utility computing service and billing model
- ✓ Automation of administrative tasks
- ✓ Dynamic scaling
- ✓ Desktop virtualization
- ✓ Policy-based services
- ✓ Internet connectivity

## 2.18 Security in Infrastructure as service

Infrastructures as a service associated risks are not new and can be found in the computing environments.There are many companies and organizations that outsource significant parts of their business due to the globalization.

Infrastructure as a Service security challenges categorized into two Security threats sourced from host and Security threat sourced from host (Wesam, Ibrahim, & Christoph, 2014).

Security threats sourced from host is Monitoring VMs from host, Communications between VMs and host, VMs Modification and security threats sourced from host are trusted cloud computing platform, trusted virtual Datacenter and Mandatory Access Control.

Security threats sourced from VM are Monitoring VMs from other VM, Communications between VMs, Virtual Machines Mobility, Resources Denial of Service and VMs provisioning and migration and security threats sourced from VM IpSec, Encryption and VPN.

## 2.19 Ethiopian Banks IT Infrastructure Development

Ethiopian banks invest huge amount of money for their IT infrastructure. This includes building datacenter and disaster recovery, network, storage, server and other related equipment for their core banking and other systems. This investment with each bank has challenges

### 2.19.1 Challenges of Infrastructure development in Ethiopian banks

The following are some of the challenges of disperse infrastructure development in Ethiopian banks.

A) Each banks need to assign dedicated person for each administration of their infrastructure
B) Huge investment costs on each bank for investment of their infrastructure
C) As data increases the need to hardware requirement also increases
D) Focus on their infrastructure than profit maximizing tasks
E) Administration problem for capable and competent person may not be available for all banks.

## 2.20 Benefits of Virtualization Technology for Financial Industry

According to the study (Kizza, 2012) Africa Can Greatly Benefit from Virtualization Technology. The Benefits of Virtualization for African Institutions minimization of hardware costs, save on energy, faster server provisioning, provision of better and faster disaster recovery, better load balancing, creating a better and faster software testing environment, Increase uptime, Isolate applications, extend the life of older applications.

According to Scroggins (2013) benefit of Virtualization allows for maximizing of hardware through sharing of resources and virtualized environment is also easier to backup and restore for disaster recovery purposes (Scroggins, 2013).The following are some of the benefits of virtualization technologies practice Infrastructure as a Service benefits for Ethiopians banking industry.

### 2.20.1 Cost savings

An obvious benefit of moving to the IaaS model is lower infrastructure costs. No longer do banks have the responsibility of ensuring uptime, maintaining hardware and networking equipment, or replacing old equipment. IaaS also saves banks from having to buy more capacity to deal with sudden business spikes. Organizations with a smaller IT infrastructure generally require a smaller IT staff as well.

The pay-as-you-go model also provides significant cost savings. Because IaaS use is metered, organizations pay for only the capacity needed at any given time. This method also allows them to avoid large fixed monthly or annual fees for benefits they may not use. The IaaS model demands no upfront charges, bandwidth utilization fees or minimum term commitments.

### 2.20.2 Scalability and flexibility

One of the greatest benefits of IaaS in Ethiopian banks is the ability to scale up and down quickly in response to an enterprise's requirements. IaaS providers generally have the latest, most powerful storage, servers and networking technology to accommodate the needs of their customers. This on-demand scalability provides added flexibility and greater agility to respond to

changing opportunities and requirements. This is especially helpful in building and dismantling test and development environments, which greatly benefit from this increased speed and agility.

### 2.20.3 Faster time to market

Competition is strong in every sector, and time to market is one of the best ways to beat the competition. Because IaaS provides elasticity and scalability, organizations can ramp up and get the job done (and the product or service to market) more rapidly.

Support for DR, BC and high availability: While Ethiopian banks has some type of disaster recovery plan, the technology behind those plans is often expensive and unwieldy. Organizations with several disparate locations often have different disaster recovery and business continuity plans and technologies, making management virtually impossible. IaaS provides a consolidated disaster recovery infrastructure, reducing costs and increasing manageability. If disaster strikes, employees can access the same infrastructure they have always accessed via an Internet connection, from wherever they happen to be. This includes everything the organization needs to function as usual — email, web servers and critical applications. The result: quick recovery with no loss of data.

### 2.20.4 Focus on Business Growth

Time, money and energy spent making technology decisions and hiring staff to manage and maintain the technology infrastructure is time not spent on growing the business. By moving infrastructure to a service-based model, organizations can focus their time and resources where they belong, on developing innovations in applications and solutions.

## 2.21 Overview of IaaS Resource Management framework & framework for secure cloud computing

For this study, the adopted Resource Management Framework and framework for Secured Cloud Computing Model of (Metwally, 2016) and (kashif & Sellapan, 2013)respectively. The following points describe resource management framework and framework for secured cloud computing based on these authors in detail.

### 2.21.1 IaaS Resource Management framework

#### 2.21.1.1 The Main Objective of IaaS Resource Management framework

- Need to manipulate diverse and heterogeneous resources
- Understand multiple objectives for both customers and CSPs
- Handling scalability issues
- Improve their resource utilization and maximizing profit
- Developing a multi-layered framework for constructing and managing efficient IaaS

#### 2.21.1.2Architecture of Infrastructure Resource Management Framework

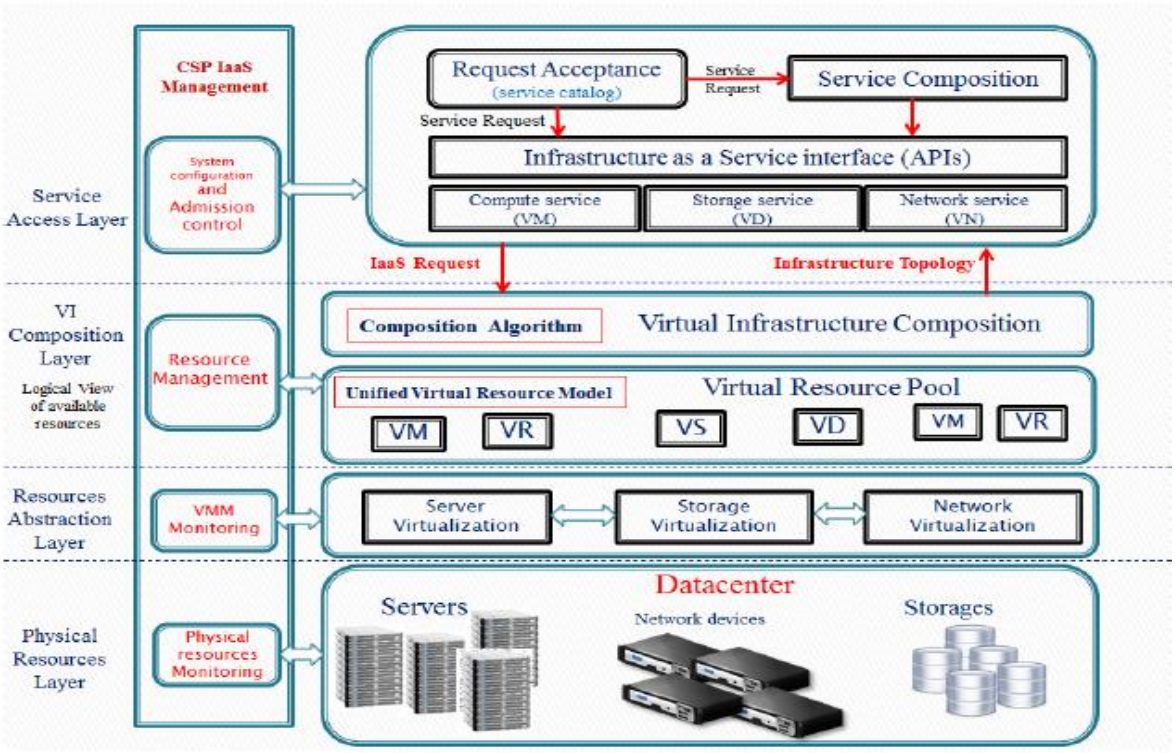


**Figure 2.5 :IaaS Resource Management Framework architecture**

### 2.21.1.3 Components ofIaaS resource management framework

The fundamental layer of IaaS resource management framework is

1. Service Access Layer
2. Virtual Infrastructure(VI) Composition Layer
3. Resource Abstraction Layer
4. Physical Resource Layer

**1) Service Access Layer**

- The upper layer of IaaS resource Management Framework.
- It is exposed to the customers' IaaS requests and concerned with the direct interaction with the customers, receiving and provisioning services.
- The mandatory functionalities in this layer are service publishing catalog, the admission control service, and the request translation service.
- This layer is responsible for publishing the CSP services in a catalog.
- The customer explores the published catalog and submits the request based on the published services.

2) **Virtual Infrastructure (VI) Composition Layer**

- This layer is the core layer in this architecture, and mainly works on resource-level manipulation.
- This layer is considered to be the most important layer in the architecture
- Collecting all the created VRs from Resource abstraction layer into a repository announces the creation of the pre-prepared virtual resource pool
- A VR is an intermediate abstraction level between the physical resources on the lower layers and the service API on the upper layers.
- As the abstraction increases while moving up, it is better to manipulate VRs than physical resources.

- Also, for efficient resource management, manipulating resources at the virtual level contributes to better management and gives more flexibility in treating resources.
- In this layer, the defined unified VR model abstracts the physical layer resources.
- This Layer consider in that model sufficient information from physical resources to ensure management efficiency. The generated VRs are then collected to create the virtual resource pool.

3) **Resource Abstraction Layer**

- The main functionality of the resource abstraction layer is to convert the physical resources to VRs that possess all the features of the physical resources.
- In this layer, different virtualization techniques for cloud resources and network resources are applied.
- The main functionality of the resource abstraction layer is to convert the physical resources to VRs that possess all the features of the physical resources.

**4) Physical Resource Layer**

- Physical layer is described as a datacenter facility that is comprised of physical resources like servers, storage and network devices.
- This datacenter is owned and managed by the service provider, and the number of available resources depends on the size of the datacenter.
- Physical resources at the lowest level are the most complex to operate and share among multiple users.
- Physical layer is comprised of heterogeneous diverse resources, where several existing hardware details do not need to be visible to users, so a level of abstraction is needed.

### 2.21.1.4Advantage of IaaS resource management framework

IaaS resource management framework helps for

- Better resource utilization
- Scalability
- To Increase their profits

- Cost-efficient model for distributed infrastructure
- Flexible interface, lower cost, and the potential benefits of the proposed solutions in terms of satisfying the customers' requirements
- Overcome management challenges

## 2.21.2 Framework for Secure Cloud Computing

### 2.21.2.1 The Main Objective of Framework for Secure Cloud Computing

- The main objective of Framework for Secure Cloud Computing to solve security problems
- It is an important aspect of quality of service providers.

### 2.21.2.2 Framework of Security Model for Cloud Computing Overview

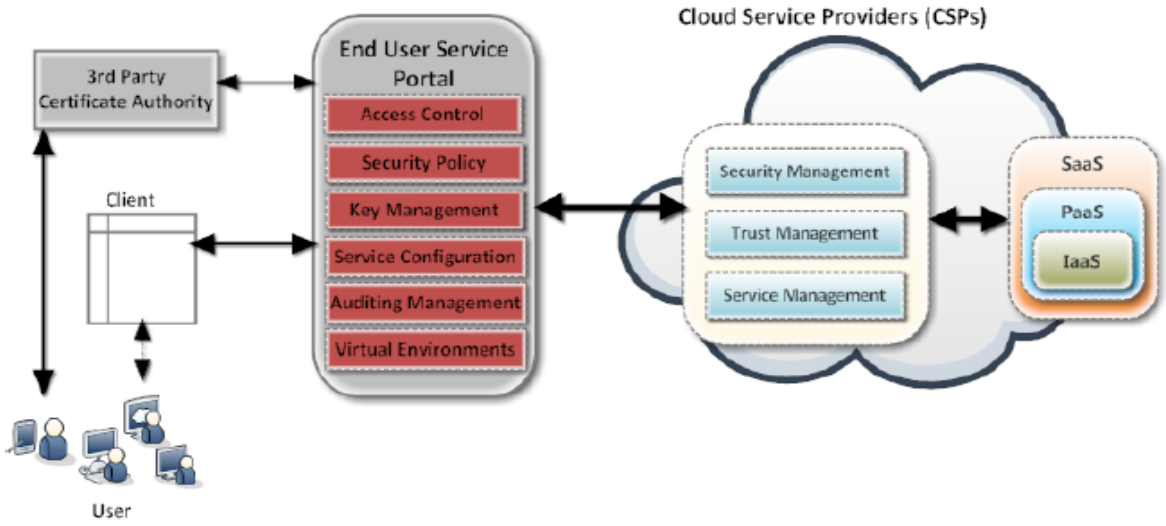


Figure 2:6 Security Model for Cloud Computing

### 2.21.2.3 Components of Security Model for Cloud Computing

**Client**: Users could access the client side (i.e web browser or host installed application) via devices
**End user service portal**: This is the portal users could use services without limitation of service providers.

**Single Sign-on (SSO**): This enables user to access multiple applications and services in the cloud computing environment through a single login, thus enabling strong authentication at the user level.

**Service Configuration**: the service enabler makes provision for personalized cloud service using user's profile. This user's profile is provided to the service management in cloud service provider for the integration and interoperation of service provisioning request from user.

**Service Gateway, Service Broker**: a service gateway manages network resources and VPN on the information lifecycle of service broker.

**Security Control**: this component provides significant protection for access control, security policy and key management against security threats.

**Security Management**: provides the security and privacy specification and enforcement functionality. The authentication and identity management module is responsible for authenticating users and services based on credentials and characteristics

**Trust Management:** this is the idea is that the more services a cloud service provider provides the higher trust level needs to be established.

**Service Monitoring**: An automated service monitoring systems to guarantee a high level of service performance and availability.

### 2.21.2.4 Advantage of Security Model for Cloud Computing

The advantage of Security model for cloud computing provides secure connection and convenient to the user for accessing to the cloud service.

## Related Work

AlemayehuAbereMulu (2014) has studied a research that focus on developing an integrated cloud computing framework for Ethiopian Banking Industries. In this study, the result of his work focus on Integrated cloud computing framework on IaaS,PaaS and SaaS. Accordingly, his finding has shown some application or systems of banks move to cloud Ethiopian service provider and some of applications to be run inside the banks industries. However, these researcher studies findings not resolve completely the problem of Investment Cost of infrastructure for EBI's.

On the other hand Getnet (2017) conducted a research that focus on datacenter virtualization framework in banking specifically for Wegagen bank but his focus area is client or desktop virtualization which has completely different intention than IaaS framework of this study.

Desktop virtualization is a technology in which the user's desktop is stored on a remote server allows a user to access his desktop from any device and location using his/her username and password for the purpose of minimizing data theft. However, other virtualization technology not included in this study and the problem of reducing investment cost of hardware, infrastructure and other datacenter equipments efficient utilization and allocation of resources not resolved completely in this study.

HailemariamAdmasu (2018) conducted a research that focuses on developing DataCenter Virtualization Framework specifically for Amhara Regional Health Bureau focused only Server Virtualization types. Other virtualization types like storage, network and application virtualizations and assessment of user's satisfaction on the virtualized environment not covered in this study.

GaniZoga (2012) conducted a research that focus on Virtualization and shared infrastructure datastorage for IT in Kosovo institutions. However, the main aim of the researcher study focus only related to reducing expenditure of budget of Kosovo, increasing a security and secures business continuity. However, this study not covered implementing a National DCs, creating a virtual infrastructure in National DCs and Data Centralization concepts.

Nyamweya (2013) conducted a research that focuses on Server virtualization framework in case of selected government ministries, Kenya. This research aimed at developing a framework to be used for implementation of server virtualization. However, the impact of integrated server virtualization framework and assessment of customer satisfaction listed as further research.

Therefore, considering these previous points of prior research and identified gaps of related works summarized using the following table for better understanding.

**Table 3.1: Summary of Related Works**

| Author, Title & Year | Objective /purpose | Approaches / Methodologies | Key Findings | Recommendation & Future work | Remark |
|---|---|---|---|---|---|
| Alemayehu AbereMulu , A Cloud Computing Framework for Ethiopian Banking Industry, (2014) | The study was to examine existing ICT infrastructure and usage in Ethiopian banking industries. . | Design science research methodology with qualitative data analysis | Develop an integrated cloud computing framework for Ethiopian banking Industries | Further work needs to be done in order to realize the proposed framework to Ethiopian Banking Industries.<br>• What different capabilities of business models require from the services provider. | The research stated as a future studies Exploring possible cloud service. assessment of different capabilities of business models require from the services provider |

| | | | | | |
|---|---|---|---|---|---|
| Getnet Worku , Data center virtualization framework in banking sectors, (2017) | To propose a virtualized data center framework specifically for wegagen bank | Design science research methodology with qualitative data analysis | Develop data center virtualization framework in banking sector: the case of wegagen bank s.c | Further work is recommended to be done in order to recognize the proposed framework<br>• Exploring security models of virtualization implementation models<br>• What different capabilities and service models are required from the services provider | The research is focused on desktop/client virtualization. . |
| Hailemariam Admasu, Data Center Virtualization Framework For Amhara Regional | For developing a data center virtualization framework for the regional health bureau | Design science research methodology with qualitative data analysis | Propose Server Virtualization framework for Amhara regional health bureau | Further work is recommended to be done<br>• Assessment of user's satisfaction on the virtualized environments<br>• Other virtualization | The researcher focused on server virtualization. |

| | | | | | |
|---|---|---|---|---|---|
| HealthBureau (2018) | | | | types like storage, network and application virtualizations<br>• Exploring security aspects of server virtualization by developing a model | |
| (Nyamweya, 2013), Server virtualization framework: case of selected government ministries, Kenya (2013) | This research aimed at developing a framework to be used for implementation of server virtualization | exploratory and applied a case study method where the Ministries of Energy and Finance, also the Directorate of e-Government were used as cases | She develops a framework as a series of steps from planning to support | Further research recommended on impact of the Integrated server virtualization framework and assessment of customer satisfaction | The developed integrated framework implementation model is not mentioned and the framework is not self-descriptive |

| | | | | | |
|---|---|---|---|---|---|
| GaniZoga, Virtualization and shared Infrastructure data storage for IT in Kosovo institutions (2012) | The main goals of the study reducing expenditure of budget of Kosovo, increasing a security and secure business continuity | The methodology is not that much clear. But, collection of the data regarding preparation of specifications for design and site preparation of the National Data Center | Establishing of National DCs is the most effective shared infrastructure data storage environment. This would reduce budget cost, optimize resource use, increase flexibility, and environmental impact of an overall cloud architecture | Future research should focus on<br>• Implementing a National DCs and Creating a virtual infrastructure in National DCs<br>• Data Centralization- In order to optimize resources use it is necessary to virtualize physical machines and use shared infrastructure data storage | Research study focus on reduce budgetary Expenditure of Republic of Kosovo institutions. |

# Chapter 3

# Research Methodology

## 3.1 Overview

The main aim of this chapter is to discuss the research methodology used to carry out this research .In this study to solve the research problem, to define the deliverables, for developing the research problem, design implementation strategy for the research problems and finally developing evaluation tools to measure the performance of the resulting data the research method used is Design Science Research (DSR).

The DSRM approach used and intended for this study to develop and implement a framework that helps for EBI's. Thus, the Data Collection Methodology used to solve the research problems observation, interview, document analysis and review of relevant literature including similar studies with data analysis techniques is presented in this chapter.

## 3.2 Research Design

A research design is a plan, structure and strategy of investigation conceived as to obtain answers to research questions or problems (Kumar, 2011).It is the conceptual structure within which research is conducted and constitute the blueprint for the collection, measurement and analysis of data (C.R, 1990).

Research design articulates what type of data is required, what techniques of data collection will be used and how the data will be analyzed (C.R., 2004). Both data and methods, and the way in which these will be configured in the research, need to be the most effective in producing the answers to the research. Therefore, for this study the research method used is DSR.

## 3.3 Research Methodology

Research methodology is a way to systematically solve the research problem (C.R.kothari, 1990). It may be understood as a science of studying how research is done scientifically (Kumar, 2008). The research method used in this study is based on the design science paradigm in IS research.

### 3.3.1 Design Science Research Methodology

Design Science is important in a discipline oriented to the creation of successful artifacts (Peffers, Tuure, Rothenberger, & Chatterjee, 2014). DSR focuses on creating and evaluating innovative artifacts that enable organizations to address important information related tasks (March & Smith, 1995).

According to Ken, Tuure,Marcus,& Samir (2007)DSRM here incorporates principles, practices, and procedures required to carry out such research and meets three objectives it is consistent with prior literature, it provides a nominal process model for doing DS research, and it provides a mental model for presenting and evaluating DS research in IS.

Design Science research is a prescription-driven and problem-solving paradigm that seeks to create viable artifacts in the form of a construct, a model, a method of an instantiation or design artifacts which provide solutions for management problems (Peffers, Tuure, Rothenberger, & Chatterjee, 2014).According to this authors DSRM comprises of six subsequent activities namely:

1) Identify problem and motivate
2) Define objectives for a solution
3) Design and development
4) Demonstration
5) Evaluation
6) Communication

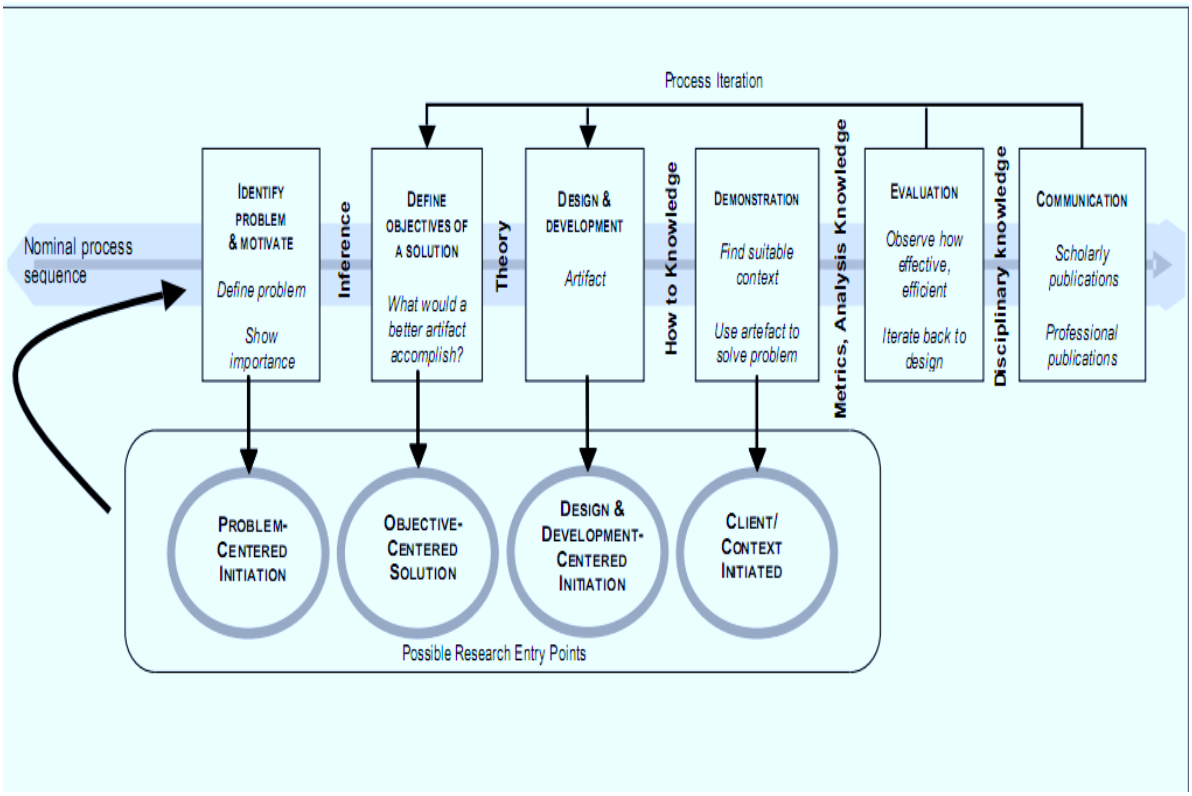


Figure 3.1: DSRM Process Model (Peffers, Tuure, . Rothenberger, & Chatterjee, 2007)

### 3.3.1.1 Identify problem and motivate

#### 3.3.1.1.1 Identify problem

This is the first step in the process model of DSRM. This phase includes defining the research problem with the proposed solution.

In this study, the researcher begun defining the research problem and justify the value of a solution through assessment of gaps of prior research related to this study ,observation ,conducting interviews with domain experts and literature review on virtualization technology using integrated IaaS framework for banking sector.

Based on the problem defined the researcher proposed an effective solution by analyzing the problem domain. The values of the solution motivate the researcher to follow the solution and accept the result and to understand the reasoning associated with the researcher understanding of the problem.

#### 3.3.1.1.2 Expert interview

According to C.R.kothari (1990) there are two types of background research primary and secondary research. Primary research involves the study of a subject through firsthand observation and investigation and secondary research involves the collection of information from studies that other researchers have made of a subject.

To collect primary data Observation is one way and it is a purposeful, systematic and selective way of watching and listening to an interaction or phenomenon as it takes place (Kumar, 2011).On the other hand according to Kumar (2011) interview also another primary data collection techniques and commonly used method of collecting information from people.

**Observation**

Observation, as the name implies is a way of collecting data through observing. It is the researcher observes phenomena of interest in the environment studied to draw information which was not obtainable from other methods (Khairul & Mohd, 2008).

Observation as a data collection method can be structured or unstructured. In structured or systematic observation, data collection is conducted using specific variables and according to a pre-defined schedule. Unstructured observation, on the other hand, is conducted in an open and free manner in a sense that there would be no pre-determined variables or objectives (Lynn & Ronald, 2010)**.**

**Interview**

Interviews are a systematic way of talking and listing to people (Nyaoro, 2012)**.** There are three different types of interviews structured, semi structured and unstructured (P., K., E., & B., 2008).

According to Kumar (2011) Structured interview the researcher asks a predetermined set of questions, using the same wording and order of questions as specified in the interview schedule and structured interviews consist of a series of pre-determined questions that all interviewees answer in the same order.

On the other hand unstructured interviews allow flexibility in objectives, design, sample and the questions that you plan to ask of respondent's aspects of the process. This interview is usually the least reliable from research viewpoint, because no questions are prepared prior to the interview and data collection is conducted in an informal manner.

According to Khairul& Mohd (2008) semi structured interview offers sufficiently flexiblity to approach different respondents differently while still covering the same areas of data collection.

Semi-structured interviews simply a conversations in which you know what you want to find out about and so have a set of questions to ask and a good idea of what topics will be covered but the conversations is free to vary and is likely to change substantially between participants.

Semi-structured interviews contain the components of both, structured and unstructured interviews. In semi-structured interviews, interviewer prepares a set of same questions to be answered by all interviewees. It provides a clear set of instructions for interviewers and can provide reliable, comparative qualitative data.

After carefully understanding each types of interview method semi-structure interview method was selected for this study because it is most suitable to give the researcher flexibility and this flexibility was important to obtain rich information from the interviewers about the subject.

Interviews were conducted between April 16 and April 25, 2018 and responses were obtained from all selected informants. The objectives and concepts of the study were briefly explained for interviewees and each informant was interviewed individually by the researcher. Interview questions are prepared by adapting others work from various literatures and modifying for the specified case

This research has preferred to use primary data collection method observation and semi structured interview for different reasons. Firstly, primary data is up to date/fresh and helps to gather appropriate data from the respected bodies. Secondly, primary data collection method for identifying the real requirements of banks, to get in-depth opinion from

participants, to gain a better understanding of the participant's environment, respondents to have adequate time and to give well thought answer.

For the purpose of this study interviewing the best suitable respondents selected through purposive sampling are used as information acquisition method. Purposive sampling is used in data collection, which means that the best suitable respondents are chosen in order to understand some activity or phenomenon better and discover new viewpoints instead of making statistical generalizations. But, Gathering data from the total population is time taking and expensive. So, sampling method is preferable.

Sampling techniques provide a range of methods that enable to restrict the amount of data needed to collect by considering only data from a subgroup rather than all the population and finally generalizing the result of on whole population

**Sampling method**

Sampling means selecting a given number of subjects from a defined population as representative of that population (Prabhat & Meenu, 2015).There are two main types of sample probability and non-probability sampling (DAWSON, 2002).

In probability sampling, all people within the research population have a specifiable chance of being selected whereas non-probability samplings are used if description rather than generalization is the goal (C.R.kothari, 1990) .According to C.R.kothari (1990), in non-probability sampling the investigator may select a sample which shall yield results favorable to his point of view.

Therefore, for this study the researcher used non-probability sampling methods in order to understand the phenomena and the best suitable respondents to be chosen from selected banks instead of making statistical generalization. Also purposive sampling is better for this study to gather data from the experts who are familiar with the topics in detail, helps for the researcher to select information rich cases for study and it is a method where by a researcher selects sample based on experience or knowledge of the group to be sampled.

For conducting purposive sampling, a researcher has something in mind and participants that suit the purpose of the study are included. Purposive sampling enables to use judgment to select case that best enable to answer questions and to meet the objectives.

For this study three banks are selected for interview. These are National Bank of Ethiopia (NBE), Commercial Bank of Ethiopia (CBE) and Abyssinia Bank (BOA) using early virtualization technology implementation date in the DCs as criteria of which in turn helped the researcher to acquire in depth insight for the study.

A total of 12 interviewees from NBE, CBE and BOA were interviewed. The data collection method utilized was semi structured interview which is done individually for all of the interviewees.

| **Name of Selected Banks** | **Respondents** | **Types Of Virtualization** | **No. of Respondents Selected** |
|---|---|---|---|
| NBE | Information System Management Directorate | Server Virtualization | 1 |
| | Chief Infrastructure Network and System Managers | Server Virtualization | 1 |
| | Chief ICT Security | Server Virtualization | 1 |
| | Chief Information Technology Project Research Officer | Server Virtualization | 1 |
| | Senior Network administrators | Server Virtualization | 1 |
| | Senior System Administrators | Server Virtualization | 3 |
| BOA | Senior System and Database administrator | Server&Desktop Virtualization | 2 |
| CBE | Senior System and Database administrator | Server Virtualization | 1 |
| | Associate technical IT officer | Server Virtualization | 1 |
| | | **Total** | **12** |

**Table 3.2 Sampling for Interview**

### 3.3. 1.2 Define objectives for the research

This is the second step in design science research process models. In this stage the study aims to identify the requirements for developing the proposed IaaS framework from the state of problems. After identifying a problem and pre-evaluating its relevance, a solution has to be developed in the form of a framework.

After data was collected from respondents, it should be narrated and summarized. This involves data preparation, analysis, and finally data interpretation. The analysis technique used in this study is thematic analysis technique in which the result of interview was grouped in to main categories. Finally appropriate generalization is made and presented accordingly for the qualitative data by way of narrating and interpreting the situations.

#### 3.3.1.2.1 Data Analysis Techniques

According to Kothari (1990), researcher may review two types of literature: the conceptual literature concerning the concepts and theories, and the empirical literature consisting of studies made earlier which are similar to the one proposed.

In this study literatures on concepts of virtualization technology and other similar studies were reviewed. Accordingly interview and review of relevant literature are employed for this study to develop the knowledge bases required for developing the proposed IaaS framework.

The researcher collected relevant information after interviewing all selected informants for this study. The collected data was described, organized, analyzed and interpreted for better understanding the current situation.

Thematic analysis technique is employed, which means that the result of interview was grouped in to main categories for formulating a problem and developing the working framework from an operational point of view.

In this study the analysis is made based on two components. First, data collected from interview and second one is literature review conducted in related works. Consequently, by analyzing this two this study presents a requirement to construct the proposed framework.

### 3.3. 1.3 Design and Development

Design science research should produce a feasible artifact in the form of models, methods, constructs and instantiations (Hevner, March, Park, & Ram, 2004). Frameworks are useful tools which indicate the relevant decision making variables and these variables interact with each other to achieve the objective (Vikram & Sarvjit, 2017).

A framework is a model artifact that provides a broad overview or skeleton of interlinked items which helps as a guide to achieve the specific objective.

Based on Hevner (2004), there is seven step guideline to be followed in order to work on IS researches with an output of IT artifacts. He also recommended researchers to use their creative skills and judgment to determine when, where and how to apply each of the guidelines in a research under investigation. Accordingly, the guidelines are used in this chapter with respect to the context of this study.

In the first guideline of design science, it is stated that the output of an IS research shall be a purposeful IT artifact created to address a critical organizational problem (Hevner A. R., 2004). Accordingly, in this study, a framework is considered as a purposeful IT artifact that can address resource utilization issues, scalability, and flexibility and reduces internal operational complexity problems.

After all the above stages are completed the appropriate and suitable framework was developed based on two well-known frameworks. These are resource management framework and framework for secure cloud computing with possible modification by determining the functionality and each component to solve the existed problems in the EBI's.

For the design phase, acquired knowledge from phase one, phase two, bank expert interview analysis and literature is used as input for the proposed framework. After all the above stages are completed the appropriate and suitable framework was developed using software tools Edraw-Max.

The developed framework shows each component with its functionalities to solve the existed problems in the EBI's. Users, Service Provider, web browser, End user portal, IaaS services, virtual machine, hypervisors, Hosts and storage are the main components which are discussed in detail on chapter five.

#### 3.3.1.4 Demonstration

Demonstration is a part where the researcher used the developed artifact to solve the existed problems in a better manner through a prototyping tool including experimentation and/ or simulation.

Demonstration the use of artifact to solve one or more instances of the problem using a prototyping tool. This phase include a reflection is made on the course of the research conclusions have been drawn from the research results to answer the main research questions. This includes experimentation, simulation and other activity.

## 3.4 Validity and Reliability

The data analyzed has to test for precision of the finding and the research has to be consistent with other researches and projects which is validity and reliability respectively (John, 2009). In qualitative study Validity means "appropriateness" of the tools, processes, and data (Lawrence, 2015).

In interview one key question of validity is whether the views expressed by the interviewees reflect their experiences and opinions outside the interview situation or whether they are an outcome of the interview situation itself (Silverman, 2011).

Accordingly, to validate the accuracy of data for this study the researcher used by involving the relevant bank expert for interview and their interview result recorded and presented. Additionally, the data collected for the study needs to be accurate and interpretation of the data should avoid the researcher bias.

According to Silverman (2011) the validity of research concerns the interpretation of observations whether or not the inferences that the researcher makes are supported by the data and sensible in relation to earlier research. To provide a valid outcome the researcher considered readily available related articles and books from trusted sources and given by relevant respondents in order to avoid bias.

According to Leung (2015) the essence of reliability for qualitative research lies with consistency. From the reliability point of view the research used primary data to be collected.). Therefore, for this study the researcher used experts interview and benchmark other experiences in order to produce reliable outcomes.

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# Chapter 4

# Finding and Discussion

The preceding chapter discussed the research methodology adopted for this study. The intention of this chapter is to present, interpret and analyze data obtained from primary and secondary sources.

The Respondents of the study have a direct relation with the virtualization technology implementation in the banking industries who are Information System Management Directorate, Chief Infrastructure Network and System Managers, Chief ICT Security, Chief Information Technology Project Research, Senior Network administrators, Senior System Administrators, Database administrator and Associate technical IT officers.

A total of 12 interviewers from NBE, CBE and BOA were selected for interview. The data collection method utilized was semi structured interview which helped the researcher to acquire indepth Insight for the study.

The result of interview is presented by comparing interview finding against the relevant literature findings. For this reason, this chapter contributes a lot for the design and development phase of design science research methodology.

## 4.1 Interview Interpretation

The main purpose of this interviews interpretation is to present the views and ideas of the respondent related to deployment of virtualization technology. The result of the interview finding helps for identifying each problem of the study. Analysis of the collected data from interview done by the researcher and Interview questions were prepared by adopting from literatures and modified according to this study.

The main components that are needed to be analyzed and interpreted from interview findings for identifying the benefit, challenges and to identify improvements aspects of virtualization technology practices in the banking sector are broadly categorized into four main sections.

This includes

- Main Reasons or driving forces for the implementation of virtualization technology in EBI
- Benefit and Challenges with the adoption of virtualization technology in EBI
- Factors that affect the decisions for implementing IaaS Framework.
- Outcome of IaaS framework

### 4.1.1 Main Reasons or Factors for the implementation of virtualization technology in EBI

As per interview result in case of Ethiopian Banking Industry virtualization technology is mainly deployed for cost optimal purposes. Since the banking industry services expanding, purchase, setup of hardware devices for newly purchased systems, to decrease power consumption, reduce cooling requirements of DCs and other related costs inside the datacenter EBI's implemented virtualization technology in the DCs.

In addition to cost reduction banks experts explained that virtualization technology implemented in the DCs for administration simplicity, to centrally manage systems with less human power, to reduce non-virtualized DCs infrastructure administration challenges, for effective utilization of resources, to deploy and to take the advantage of this latest technology.

According to the study by Rakesh & Shilpi(2015)indicated that a reason for virtualization technology deployment is to Saves money, Resource optimization, to decreased power consumption and datacenter consolidation, reduces system administration work, to simplify management, for Maximizing Uptime, Software installation easier, to Increase CPU utilization, Better use from hardware and Good for the environment.

Therefore, this result was consistent with bank expert interview. According to the majority of banks expert result and related literature finding indicates that the main driving force for the implementation of this technology are cost saving, effective utilization of resources, administration simplicity, scale up and to reduce non-virtualized DCs infrastructure administration challenges.

### 4.1.2 Benefit of Virtualization Technology

Before discuss the benefit of virtualization technology in the banking industry interview result when banking industries implemented virtualization technology, which virtualization technology types banking industries implement discussed.

According to interview result indicate that CBE implemented server and desktop virtualization since 2 years ago, NBE and BOA implemented server virtualization before a year ago.

Thus the result from interview revealed that the benefit of virtualization technology of practical implementation helps for EBI to run number of systems on limited servers, able Idle resources to be shared between applications, resources could be managed centrally, Less energy consumption in the DCs, Less space, cooling and power consumption of DCs, simple to manage all servers using less human power, proper utilization of resource, easy to add ,locate the resources to each application, simple for system administration, high availability and to make the installation easier.

On the other hand, according to some bank expert's interview result indicates that in a non-virtualized DCs infrastructure, the DCs equipment like servers, storage and other DCs equipment's procured from different vendor supplier for each different systems item inside the DCs. However, implementing this new technology in the DCs somehow enable heterogeneous DCs equipment's of non-virtualized DCs infrastructure all in one server.

In addition, to the above points bank experts explained that adopting virtualization technology in a banking industry has given relative advantage over its competitors. As per Banks experts explanation virtualization technology able the banking industries to effectively utilize resources, to implement banks systems using less resources, to have less cooling facility in the DCs, less power supply, better management, less space , less man power for the management and able the banking industries to give high quality of services. This leads adopting virtualization technology in the banking industries relative advantage compared with banks not implemented virtualization technology yet.

Another important point bank expert explained that the benefit of virtualization is that if one server fails automatically another machine will take the jobs and this leads virtualization technology enable for the banking industries to give high quality of services and helps for banking industries to reduce any interruption on business continuity.

On the other hand, some interview result indicated that most banks implemented virtualization technology for cost minimization of infrastructure investment. However, the interview finding suggested that virtualization may not only be suitable for cost reduction benefits but also to ensure higher utilization of computer resources. Related to this concept, some of respondent explained that after the implementation of virtualization technology in the DC's cost of server investment equivalent with the traditional non virtualized infrastructure investment.

However, as per their explanation during virtualization technology implementation the server's requirement to install this technology needs high capacity of machine. In contrary, in a non-virtualized environment the Server requirement is low. Therefore, according to expert practical interview result show that cost minimization not only related to the investment cost of server instead costs of operational expense.

According to Shrithi& Vanamala (2014) virtualization technology helps for effective utilization of resources, lower the investment cost of hardware, Low Level of Maintenance and Management and reduce the cost of operation.

On the other hand according to Pooja, Renuka, & Tejinder (2013)the benefits of virtualization such as reduced downtime, better hardware utilization, high availability, flexibility, reduced downtime, cost effectiveness and scalability.

According to Radhwan & Asmaa(2013)virtualization technologies in the DCs helps a way to improve system security, reliability and availability, reduce costs and provide greater flexibility. According to related studies had been done on improving DCs resource management deployment and availability with virtualization Wood (2011) studies shown that virtualization provide powerful, application techniques to improve data center agility, efficiency, and reliability. According to the finding of Scroggins (2013)studies virtualization allows for maximizing of hardware through sharing of resources.

Result of above literatures was consistent with the finding of banks interview. Therefore, this practical result of implementation of virtualization technology in banking industries result indicates that the benefit of virtualization technology allows for maximizing of hardware resources, for effective utilization of resource, less energy consumption in the DCs, reduce the cost of operation, reduced downtime, high availability, flexibility, scalability, improve reliability, availability, easy to manage all servers using less human power and reduce management Complexity.

### 4.1.3 Challenges of virtualization

The challenges of virtualization technology in the EBI's according to interview finding indicate that implementing a virtualization technology needs skilled human power and training. As per their explanation the biggest challenges during implementation of virtualization technology preparing architecture design as per bank requirement, design physical and network connection as per this technology requirement was a main challenges.

Another discussed points related to this challenges before the implementation of virtualization technology technological readiness seen on feasibility study of hardware and software were considered. However, according to bank experts indicate that there is a challenge related to environmental and organizational factors. The Environmental factors were some peoples unable to accept this technology and allocation of necessary resources of systems as main factors. On the other hand allocation of necessary budget and preparation of server specification was the main factors related to the organizational perspectives.

And also a main points related to this bank experts pointed out as a challenge related to the adoption of virtualization technology was local partner has limited skilled human power.

Implement Server virtualization in organization has major drawbacks in management and failure to consider the overall effect of server virtualization on IT equipment such as storage, network in the DCs can result unwanted consequences such as management complexity. This is because every new technology is associated with a learning curve and server virtualization may require considerations of expert skills and IT infrastructure management before its implementation (Abiodun & Kevin, 2017).

Therefore, according to EBI's implementation of virtualization technology has a challenges related to skilled human power (Internal Staff and local Vendors), and related to environmental and organizational factors. This interview result was consistent with result of above literatures. Therefore, the implementation of virtualization technology in the DCs requires consideration of experts IT skilled human Power and training.

### 4.1.4 Factors affecting the decision for implementing IaaS framework

To identify the requirement of banks expert and to propose effective utilization of hardware resources framework for EBI's the researcher need to assess a key factors affecting the decision for implement IaaS framework for Ethiopian Banking Industries.

According to CBE experts explained that CBE has a plan to build large standard DCs which support banking industries and other microfinance Institutions hardware requirements and to effectively utilize resources using a virtualization technology. On the other hand NBE and BOA have no any plan yet to outsource infrastructure. However, all bank experts explained that the main and the most reason for banks not to have any plan to outsource infrastructure due to customer privacy data concerns, security, and there is no well-defined, secured Ethiopian based virtualized Infrastructure as a service framework which can fulfill the requirements of banks. As per their explanation banking industries need a strategic plan to reduce ICT investment, to implement effective resource utilization mechanism and needs to reduce operational complexities.

Therefore, according to this study interview result indicate that High hardware support &maintenance cost of servers and other DCs infrastructure equipment's, to reduce organizational burden of installing and managing hardware, to reduce support time, complexity, investment of Capital, scalability and operating expenses on ICT were the main driving forces to adopt alternative solutions. While the security issues, lack of strategy, lack of policy and lack of well-defined framework to outsource infrastructure are the main barriers for IaaS adoption.

### 4.1.5 Functional Requirements for the Proposed Framework

The functional requirements of the proposed virtualized Infrastructure as a Service framework based on

- Scalability
- Flexibly
- Operational complexity
- Security

Based on the above functional requirements the researcher started to identify the type of resource management framework suitable for EBI's, deployment model, strategies how to access Infrastructure as a Services from service provider as per requirements of banking Industries identified in this study..

### 4.1.6 Outcomes of IaaS cloud computing adoption

The Finding of interview stated that for efficient utilization of resources banking industries implemented virtualization technology. However, according to expert interview result within the banking industries all hardware resources not effectively utilized because of systems of banks all not exist in a virtualized infrastructure environment.

According to interview result indicate that in CBE and BOA hardware supplier external vendor gives a maintenance support. On the other hand in NBE there is service level agreement of infrastructure maintenance with local partner. Consequently, when there is a problem on hardware, the process take some much more time and also there is another expense like telephone call to get this hardware maintenance support. Therefore, the above two points indicates that in the banking industries there is an investment cost of hardware maintenance support.

The suggestions from all respondents agreed on Infrastructure as a Service framework compared with the existing infrastructure deployment practices to support banking services an alternative solution to reduce operational complexities, to implement efficient utilization of resources in the banking industries, to reduce local/external hardware vendor support and helps to reduce the investment cost related to hardware and DCs.

Related to this concepts studies presented implementing National Data center using shared infrastructure data storage, and virtualization of hardware infrastructure in National DCs and this studies indicate that implementing National DCs enable to reduce hardware Cost, Reducing Energy consumption, security, optimizing usage of existing hardware resources and flexible infrastructure (ZOGAJ, 2012).

Saleem (2011), states that enterprises save their capital by not building their data center and not hiring employees for managing them. Along with that, flexibility and different pricing models makes Cloud Computing more cost effective for enterprises. According to Rakesh & Shilpi (2015) researcher presented that IT industries focus on virtualization has increased considerably in the past few years and the future of enterprise IT management will be based on virtual computing and virtualization makes it possible to maximize computer utilization while minimizing all associated overheads of management, power consumption, maintenance as well as physical space.

According to suggestions from all respondents and related studies the researcher proposed Infrastructure as a Service framework for EBI's.

# Chapter 5

# Proposed Infrastructure as a Service Framework for EBIS

The intention of this chapter is to present the results of analysis the researcher identified best IaaS framework for EBI. The analysis process based on banks expert's interview requirements, observation from selected banks and reviewing literatures best resource management practices. Following the results of the analysis the researcher proposed IaaS framework for EBIS that could best meets banks functional requirements, services, security and deployment model by looking other financial institutions best IaaS experience and practice. Moreover, this chapter addresses the evaluation of the proposed framework in order to ensure its applicability, efficiency and usefulness.

## 5. 1 Existing ICT limitations and challenges

According to interview result indicate that in the banking industry there is an investment cost of DCs Equipment's and ICT infrastructure, there is organizational administrative burden for install, manage operating systems and operational cost of hardware to purchase, to maintain with a support of SLA and to train capable IT staff. Thus this study presents the potential benefit and challenges of that could be brought from virtualization technology for EBI was the main objective of the study. However, according to interview result the main existing limitations

- Diversity/heterogeneity of managed resources: The data center components and facilities like compute devices, storage, network resources, UPS and other DCs equipment's supplied from different manufacturers this leads for the banking industries adds additional challenges.
- Scalability: the number of managed DCs increases a scalability issue occurs. Lack of Scalability in the banking industries may affect and impacts system performance and reduce Banks revenue.
- Flexibility

## 5.2 General Overview of Proposed IaaS framework

Implementing Ethiopian based IaaS framework allows Banking Industries to run the different workloads on the local service provider. This study considered as a significant starting point for Banking Industries to reduce operational expense related to infrastructure maintenance cost and able to have self-service.

From the perspective of service provider side the modularity and layering of the architecture provides flexibility to manage and maintain its framework efficiently and from customer side users customize their requests and easily express their requirements.

As a consequence the modular architecture provides the ability to cooperate with infrastructure service provider. And also this proposed framework provides for banking industries to create secure connection and convenient to the user for accessing the infrastructure service.

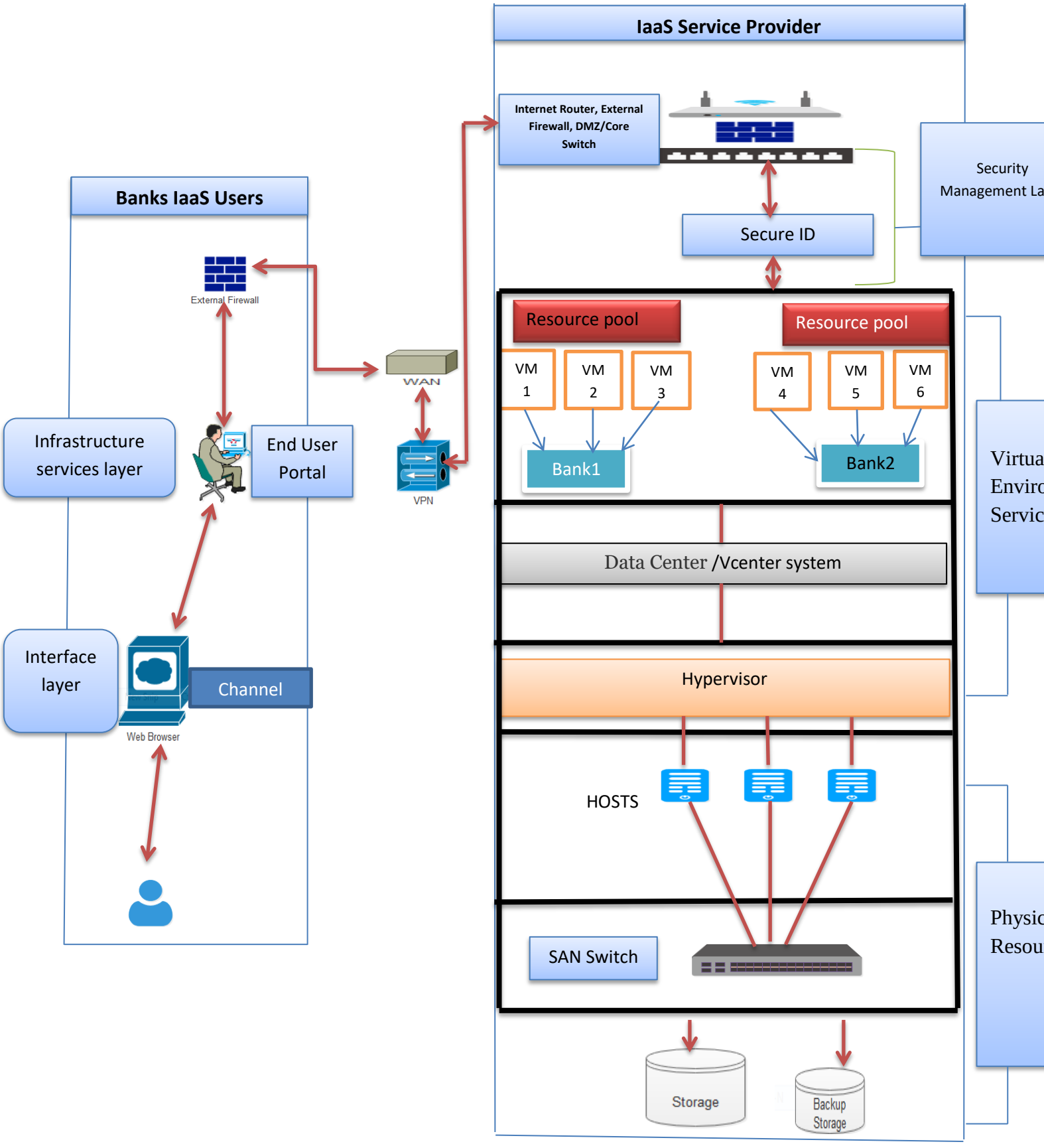
### 5.2.1 Identify IaaS Framework and Deployment Models

The researcher for identifying IaaS computing solution and deployment models that can be implemented for the EBIs' the researcher started and analyzing the requirements of selected banks by means of interview that helps for effective utilization of resource that can be provided to EBIs' by analyzing the interview result requirements of selected banks and looking other financial institutions best IaaS cloud based service experience and practice.

Following the result of analysis the researcher identified IaaS framework with private deployment model for EBIs'. The researcher decided to propose a private delivery model for EBIs by considering the knowledge derived from literatures and banks intention from interview result.

The proposed IaaS framework for EBSs' by integrating the Resource management Framework and framework for Secured Cloud Computing and deployment model that could best meet banks requirement discusses the next sub sections.

## 5.3 The Proposed Framework of IaaS Service for EBI's



## 5.4 Components of IaaS Architecture for EBIs

### 5.4.1 Interface Layer

**IaaS Clients/Users**: A user who explores the provider service catalog and access the client side of host installed virtual machine and submits an IaaS request.

**Proposed EBIs IaaS Provider**: IaaS service provider who owns the DCs and responsible for establishing the virtual resource pool, collecting the incoming requests and configuration.

**User Interface**: This layer acts as interface between client (bank users) and Infrastructure as a Service provider. Users could access the client side (i.e web browser or host installed virtual machine ) via devices with multi factor authentications provide by third party Authority. This layer acts as service portal where users get their personal cloud services.

### 5.4.2 Infrastructure Service layer

**End User Service portal** -In this portal service EBI's can securely access and use IAAS services which are provided by single service provider. This portal allow authorized user to administer, manage and deploy resource without the need to understand the underlined fabric and physical complexities.

This layer offers Infrastructure services including servers, storage and networking by local service provider. The users can use the infrastructure services virtually without buying a new DC's equipment's, managing it from the proposed EBI infrastructure services providers for virtually without buying a new DC's equipment's , managing it from the proposed EBIs infrastructure service providers.

**Servers Services**

This is a service of consolidating multiple operating systems on a single server. This service enables organizations to greatly reduce their DCs hardware and the associated costs of vast amounts of physical hardware.

**Storage Services**

Storage Services are the process of grouping the physical storage from multiple network storage devices into single storage devices. These services enhance the efficiency of storage environment, pooling of storage resources into single resources allows administrators to efficiently manage the entire storage space.

**Networking services**

Networking is a critical component in any infrastructure. This services responsible and allows a single virtual switches to connect multiple switches in a cluster for centralizing of network configuration.

### 5.4.3 Virtual Environment Service layer

The services offered in this layer include server virtualization, Storage virtualization, Network virtualizations and other types of virtualization technologies services. The main functionality of the resource abstraction layer is to convert the physical resources to virtual resources that possess all the features of the physical layer. This conversion is achieved by virtualization. Using this service EBI's reduce ICT investment expenses & reduce operational complexities, offered by the proposed local service provider based on their needs.

Virtual Resource Pool to represents the conceptual modeling of all the available resources in the managed DCs. Collecting all the created VRs from the abstraction layer into a repository announces the creation of the pre-prepaid virtual resource pool. The generated VR are then collected to create the virtual resource pool. Inaddtion, in this layer the allocation and de-allocation of VR on demand is achieved by applying several resource allocation approaches. Based on the deployment scenario the generated virtual resource pool can represent the VR of single DCs or multiple DCs in this architecture. This layer is the core and the most important layer in this architecture and mainly works on resource level manipulation.

### 5.4.4 Security Management layer

Finally, the framework has security and service management. Security management component provides the security and privacy specification and enforcement functionality and the service enabler makes provision for personalized cloud service using user's profile.

**Secure ID**: It is a device used Security services which is included in this framework responsible for authenticating users and services to control unauthorized access and protect customer data from unwanted user.

**Trust Management:** In this framework the idea to create trust between Infrastructure as a service provider and customers. Efficient cryptographic mechanisms for trust delegation involve complex trust.

**VPN**: VPN is a technology helps to create a safe, encrypted connection and allow remote users and branches offices to securely access resources.

**Key Management**- A module for protecting encryption keys from loss and authorized access. Key management is the administration of tasks involved with protecting storing, backuping up and organizing keys.

**Service configuration**-the service configuration is responsible for service enabler makes provision for personalized cloud service using user's profile.

### 5.4.5 Physical Resource Layer

Physical Resources Layer is the lowest level and the most complex to operate and share among multiple users. The physical layer is comprised of heterogeneous diverse resources, where several existing hardware details do not need to be visible to users, so a level of abstraction is needed.

The physical layer is described as a datacenter facility that is comprised of physical resources like servers, storage and network devices(e.g., switches, routers, and cables). This datacenter is owned and managed by the service provider, and the number of available resources depends on the size of the datacenter.

## 5.5 Practical Demonstration of the proposed framework

The practical demonstration of the proposed framework a researcher illustrated by deploying the selected proposed artifacts using necessary software to illustrate the proposed framework feasible, how Infrastructure as a Service provider utilizes hardware resources, how Infrastructure as a Service provider securely create virtual DCs for each banks , how to implement Resource utilization of the virtual instances and determine the number

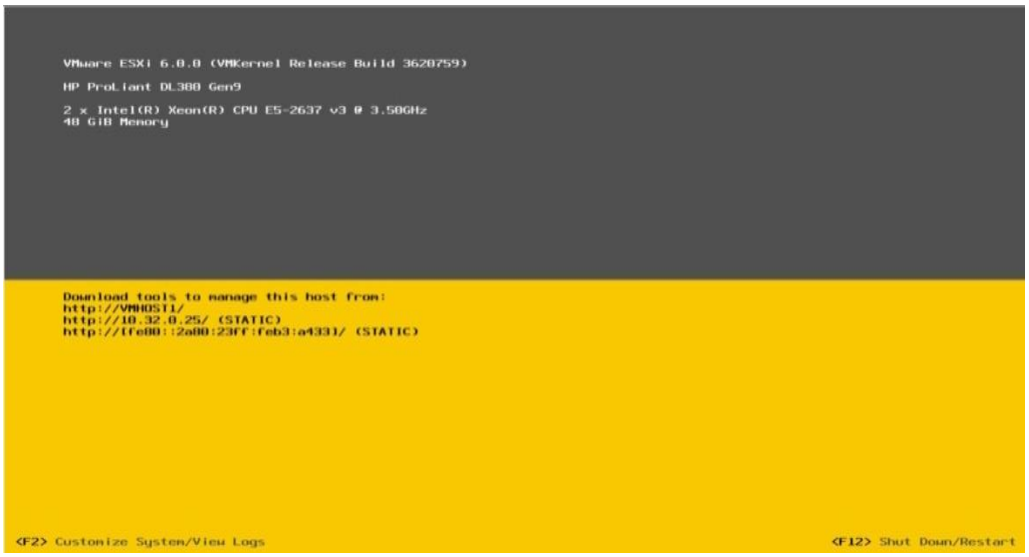
of instances to be deployed on a single physical server. The researcher demonstrated the result of experiment using Graphical User Interface.

**The following steps illustrate the mechanism for building the framework**

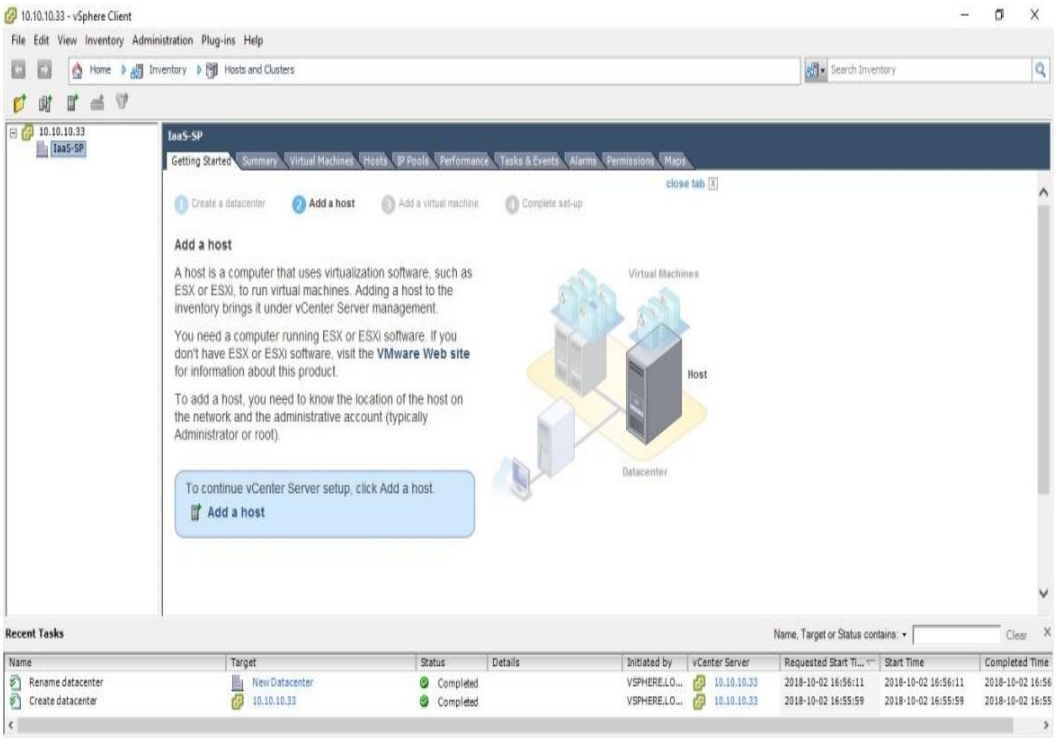
For my Demo or Test Purpose I used the below resources.

| Devices | Quantity |
|---|---|
| VMware ESXI 6.0 update 2 Operating System | 6 |
| VMware VCenter 6.0 | 1 |
| HPE ProLiant Server Gen 9 | 6 |
| HPE 3par Storage | 2 |
| SAN Switch | 2 |
| RSA SecurID | 1 |
| RSA Log Collector | 1 |

1. First installation of VMware ESXI 6.0 operating system Hypervisor to all physical servers this will help me to get all physical resource to virtual machine.

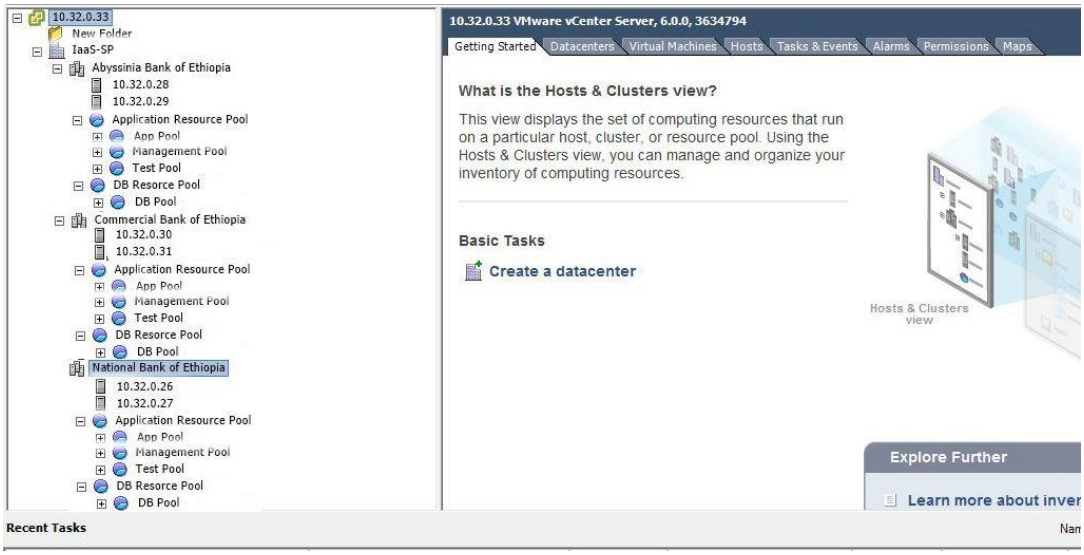



2. After installing hypervisor to all Hosts I install Vcenter Virtual Appliance and DCs to manage my hosts from a single sign on and to use Vcenter feature like VMotion , DRS, VDS and others




3. After creating DC's the next step is to create a Cluster. Creating a Cluster will help me to dedicate a physical server for a specific Bank. This means that BankA will not share any resource with Bank B. This helps for EBI's between each bank there is a Security.

4. After Creating the Cluster and adding physical hosts to Vcenter then I create resource pool for resource limitation and reservation for all application, database, test and management servers.




5. Next step is creating a virtual Machine with the requirement provided from banks.For Test Purpose the researcher used a test Sample requirement of ABYSSINIA Bank

Bank of ABYSSINIA Specification

| VM | Vcpu | Memory | HDD | NIC |
|---|---|---|---|---|
| Application 01 | 6 Vcpu | 8 GB | 250 GiB | 2 NIC |
| Application 02 | 6 Vcpu | 8 GB | 250 GiB | 2 NIC |
| Production DataBase | 10 Vcpu | 12 GB | 1 TiB | 1 NIC |
| Standby DataBase | 8 Vcpu | 10 GB | 1 TiB | 1 NIC |
| Test Application | 4 Vcpu | 6 GB | 250 GiB | 1 NIC |
| Management Application | 4 Vcpu | 6 GB | 250 GiB | 1 NIC |

6. Then create a Network Zone between Banks, with 1 VLAN for One Bank. This means there is no communication between banks
7. Then create a permission according to their cluster
8. Create username and random password
9. Assign Token serial number to RSA Secure ID appliance


10. For testing purposes VM Client application or web browser used By using the provided information form service provider
    - Ip/hostname : 10.32.0.33/Iaas-sp.lab.local
    - Username: Test01
    - Password: Test@123+Rsa SecurID code =passcode


**The following steps illustrate the mechanism for operating**

1. Client submits IaaS service Request using EBIHC Interface (End user portal).
2. The user request would be checked to verify authorization of access to the requested services.
3. If the user Request is new can issue certified token for clients to have Multi-factors Authentication and a Single Sign-on Access Token could be issued using certification of user.
4. After Received certified token End User Service Portal do Access Control, Security Policy, Key Management, Service Configuration, Auditing management and Virtual

Environment. Then the access control component share the user information related with security policy and verification with other components in end-user service portal.

5. After the client enters its credentials on End user Portal Clients could access the client side i.e web browser or host installed application End user service portal.
6. After joining service portal, user can use IaaS services which are provided by single service provider and this service enables makes provision for personalized cloud service using user's profile.

## 5.6 Benefit of Proposed Framework

Creating single Infrastructure provider the banking industries are ensured the best value services. Individual banks will see that they can obtain the most discounted rates that meet the specific technical requirements.

Therefore, the proposed virtualized IaaS framework enables the banking industries helps to minimize operational cost, to effectively manage resources, to minimize the number of external vendor support, to reduce operational complexity , easy to apply physical security of hardware, network infrastructures and virtualization infrastructure.

This study considered starting point for minimize external vendors and helps for local vendor a new opportunities .Inaddtion, the proposed framework enable data management highly in centralized location, service is highly virtualization all of which offer a much secure data service and encourage business process and activities without considering the position of equipment resources.

Inaddtion to the above points according to interview result banks not be willing to locate their customer data on external public cloud because of the fact that customer records and information must be secure and confidential. However, the need to find an alternative Infrastructure as a Service providers for EBI than external cloud service provider. Taking into account the above issue the researcher decided to propose local Infrastructure as a service provider for EBIs.

The proposed local Infrastructure as a service provider will be formed and equipped with essential IaaS technology that can be provisioned as a service to banks based on their specific application/infrastructure and other IaaS services using IaaS cloud computing model. The local IaaS provider will provide scalable, elastic and reliable resources to the users.

## 5.7Evaluation of the Proposed Framework

### 5.7.1 Framework Evaluation Approach

A framework, as a model artifact, needs to be evaluated in order to demonstrate its quality, utility and efficiency. This helps to improve the framework in an iterative manner to ensure the quality of the proposed solution so that it can solve real world business problems (Hevner A. R., 2004).

Evaluation is a central and essential activity in conducting rigorous design science research. Artifact can be evaluated using its goal, environment, structure, activity and evolution which are briefly described in the following figure 5.1 (Nicolas, Isabelle, & Jacky, 2014).

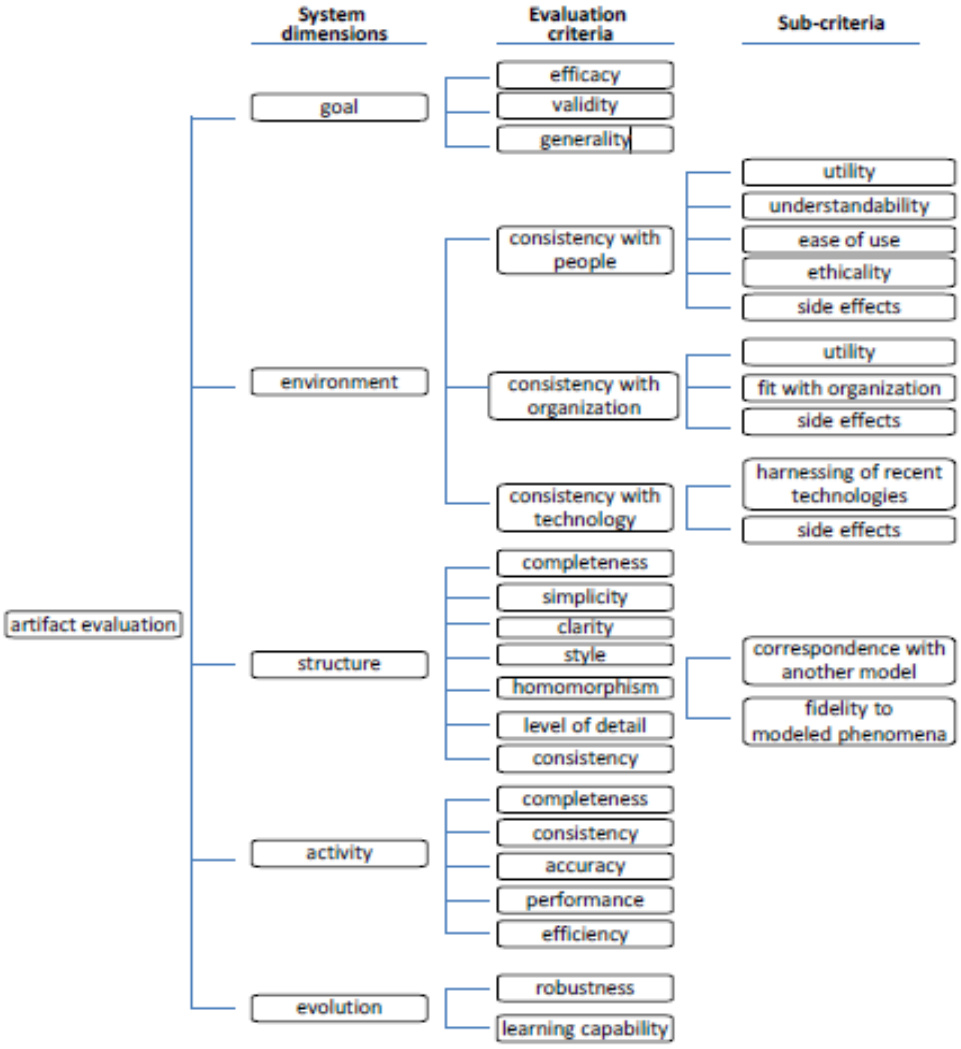



Figure 5.1: Artifact evaluation criteria

Based on Hevner (2004), there is a seven step guideline to be followed in order to work on IS researches with an output of IT artifacts. He also recommended researchers to use their creative skills and judgment to determine when, where and how to apply each of the guidelines in a research under investigation. Accordingly, the guidelines are used in this chapter with respect to the context of this study.

In the first guideline of design science, it is stated that the output of an IS research shall be a purposeful IT artifact created to address a critical organizational problem problems (Hevner A. R., 2004) .Accordingly, in this study, a framework is considered as a purposeful IT artifact that can address and improve scalability ,flexibility, Resource utilization issues.

The second guideline, Hevner (2004) indicated that the relevance of the problem must be provide evidence to support the designed artifact can be a solution to important and relevant business problems. In this study, the relevancy of addressing the problem is demonstrated in the problem statement.

The third guideline of design science defined that an IT artifact can be evaluated in terms of fit with the organization, functionality, completeness, reliability, usability, and other relevant quality attributes. An artifact can be evaluated by observational, analytical, Experimental, testing, expert validation and descriptive methods.
In this study, expert validation was used to evaluate the proposed framework along with descriptive method. Expert validation is chosen to gain different views of the Virtualization technology experts who work in EBI's. That knowledge of the experts along with their expertise in IT is believed to be crucial to gain valuable inputs. Moreover, majority of the experts have sufficient years of experience in the EBI's which adds value to their holistic view of the proposed IaaS framework.

It is also believed that the experts' experience in EBI's can help to evaluate the framework whether it fits to the organization or not. According to Hevner (2004) fit to the organization can be one of the criteria to evaluate an IT artifact.

As Hevner (2004) stated in the fifth guideline of design science research relies upon rigorous evaluation and re-construction of the design artifact in order to verify the research contributions stated in the fourth guideline.

Even though the proposed framework is not rigorously evaluated tested, the evaluation consists of two rounds. The first round of expert validation was individual discussion with selected experts to have detailed discussion and to gather additional feedbacks. Based on the expert's feedback the proposed framework was revised to improve with respect to its completeness, correctness, and clarity; and identify possible improvements opportunities.

Hevner (2004) also indicated the importance of communication of the design artifact to both technology-oriented and management-oriented audiences in the last (seventh) guideline of design science research.

After revision of the proposed framework, a second round of expert validation was conducted through a questionnaire shown in Appendix B to gather individual evaluation of the improved framework regarding the completeness, clarity and correctness of the revised framework. In this phase, additional local IT partners were invited to participate on this questioner by providing a brief explanation regarding the proposed framework.

The content of the questionnaire is derived from the evaluation criteria recommended by Hevener (2004) which consists of fit to the organization, comprehensiveness, reliability, clarity, correctness, and usability quality attributes and an attachment of the revised framework sent to the selected experts. Subsequently, the respondents were further encouraged to provide their genuine feedbacks through their personal cell-phone.

Accordingly, all the invited 14 participants completed the survey. Hence, the response rate of the framework evaluation survey is 100%. The survey data first registered in to excel and then copied to SPSS software for analysis purpose.

### 5.7.2 Evaluation result of the proposed framework

In order to evaluate the consistency of the study, Cronbach's alpha reliability test is applied and the result is depicted in table 5.1. The value of the coefficient alpha (0.860) indicates that the survey is reliable since it is greater than 0.7.

Table 5.1: Reliability Statistics based of the Proposed IaaS framework

**Reliability Statistics**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .860 | .864 | 11 |

Descriptive analysis (mean and standard deviation) of the survey result is computed as can be seen in table 5.2. The mean result of the evaluation variables is found to be greater than 3 which indicated that the respondents agreed on the clarity, completeness, usefulness, correctness of the proposed framework. The overall rating of the proposed framework is 4.2143 which represent the category of 'Very Good'. This indicates that the IT experts participated on the evaluation survey confirmed completeness, correctness and clarity, applicability of the proposed framework.

**Summary Item Statistics**

| | Mean | Minimum | Maximum | Range | Maximum / Minimum | Variance | N of Items |
|---|---|---|---|---|---|---|---|
| Item Means | 4.325 | 4.214 | 4.500 | .286 | 1.068 | .012 | 11 |

**Scale Statistics**

| Mean | Variance | Std. Deviation | N of Items |
|---|---|---|---|
| 47.5714 | 12.725 | 3.56725 | 11 |

Table 5.2: Mean and standard deviation of the Framework Evaluation Survey

**Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| The applicability of the proposed framework can improve resource utilization ,scalability, flexibility and reduce internal operational complexity | 14 | 4.00 | 5.00 | 4.5000 | .51887 |
| The organization and presentation of the framework is suitable for EBI's | 14 | 4.00 | 5.00 | 4.4286 | .51355 |
| The proposed framework is easy to be applicable | 14 | 3.00 | 5.00 | 4.2143 | .57893 |
| The content of the proposed framework is Scalable | 14 | 4.00 | 5.00 | 4.3571 | .49725 |
| The proposed framework is easy to use | 14 | 4.00 | 5.00 | 4.5000 | .51887 |
| The content of the proposed framework is relevant. | 14 | 4.00 | 5.00 | 4.2857 | .46881 |
| The content of the proposed framework is clear. | 14 | 4.00 | 5.00 | 4.2857 | .46881 |
| The content of the proposed framework is complete. | 14 | 4.00 | 5.00 | 4.2143 | .42582 |
| The objective of the framework is clear | 14 | 4.00 | 5.00 | 4.3571 | .49725 |
| The proposed framework is comprehensive in terms of coverage. | 14 | 4.00 | 5.00 | 4.2857 | .46881 |
| The implementation of the proposed framework fits with the organization problems | 14 | 3.00 | 5.00 | 4.2857 | .61125 |
| Overall rating of the proposed framework | 14 | 4.00 | 5.00 | 4.2143 | .42582 |
| Valid N (listwise) | 14 | | | | |

The evaluation result as we can see from table table 5.2 the completeness of the contents of the proposed framework and easy to be applicable scored the lowest mean value (4.2143) among all quality attributes Used to measure the Framework. This indicates the need for further improvement of the framework to ensure the Completeness of its content. The evaluation result indicated that, the applicability of the Proposed framework can improve resource utilization ,scalability and flexibility and the proposed framework is easy to use has the highest mean value (4.5) which revealed that majority of the experts Strongly agreed to it.

Similarly, the organization and presentation of the framework is suitable for EBI's are strongly agreed by Majority of the experts with mean result of 4.42. The objective of the framework is clear shows mean result (4.3571) lies under the category of 'strongly agreed' by the majority of the experts. Thus, the results of applicability of the proposed framework can improve resource utilization, scalability and flexibility and the Proposed framework is easy to use revealed the validity of the framework to be implemented in the EBI's.

In other terms, the research contributions are asserted based on the two round evaluations as stated by Hevner (2004) in the fourth guideline of design science research. Descriptive analysis (mean and standard deviation) of the survey result is computed as can be seen in table 5.2 the mean result of the evaluation variables is found to be greater than 3 which indicated that the respondents agreed on the clarity, Completeness, usefulness, correctness of the proposed framework.

The overall rating of the proposed framework is 4.2143 which represent the category of 'Very Good'. This indicates that the IT experts participated on the evaluation survey confirmed completeness, correctness and clarity, applicability of the proposed framework. Based on the above analysis evaluation result proves how the proposed framework can improve the improve resource utilization, scalability and flexibility of the existing problem in EBI's. Moreover, the completeness of the contents of the proposed framework and easy to be applicable can be considered as an improvement area to further develop the framework so that it can serve its intended goal.

In this chapter the proposed framework of Infrastructure as a service framework presented. This framework for banks enables to solve the existing problems of flexibility, Scalability, Unified, efficient management and extensibility problem. After the framework was developed it was evaluated by concerning bodies.

The next chapter will conclude the researchers work and set directions for further study

# Chapter 6

# Conclusion and Recommendation

## 6.1 Overview

The previous chapter intention was to present the results of analysis the researcher identified best IaaS framework for EBI and following the results of the analysis the researcher proposed IaaS framework for EBIS that could best meets banks functional requirements by looking other financial institutions best IaaS experience and practice. Therefore, the main purpose of this chapter is to summarize the study and also indicates future direction for other researchers.

## 6.2 Conclusion

This study was carried out to explore virtualization technology implementation practices, benefit and challenges of with the possible use of cloud computing IaaS solution and to propose IaaS Framework for EBI's. For developing IaaS framework for Ethiopian banking Industries a researcher started understanding the banks requirements through observation, interview, document analysis and looking other financial institutions best IaaS experience and practice.

The study indicates that the implementation of virtualization technology for EBI's somehow necessary to overcome the problem of scalability of information technology infrastructure investment and to improve effective utilization of resources. However, the study indicates that there is a need of framework targeted to reduce hardware maintenance support, to enhance the problem of resource utilization and scalability compare to the implementation of virtualization technology practices and reduce the operation complexity of banks internal staff.

The current state analysis of the business requirements for IaaS which arise from banking industries include cost efficiency, Scalability, Flexibility , Reliability and security. In order to meet the banking industries requirements this study identified the key elements necessary to be included in IaaS framework. Based on the current analysis the study focused search for

existing knowledge and best practices is done. The focus placed on exploring key elements in the related framework and deployment models suitable for EBIs. For building this framework, requirements collected from the selected Banking Industries, the outcomes of this framework demonstrated through simulation and compared against the research defined at the beginning of the study.

The proposed IaaS framework for EBSs' by integrating and modifying the Resource management Framework and framework for Secured Cloud Computing and deployment model that could best meet banks requirement. The researcher proposed framework meet the business requirements of EBI's and significance to improve business agility, to reduce costs associated with the IT Infrastructure, scalability, flexibility and Security concerns according to business requirements.

However , the study indicates that outsourcing infrastructure brings security concerns on customer records and information .Inaddtion, to the security concern there is a need of trust management between Infrastructure service provider and Banks and Legal Concerns. According , to this banks need to protect their customer records due to this consideration the researcher proposed Ethiopian based infrastructure service provider to create secured IaaS framework for EBI's.

The researcher proposed IaaS framework suitable for EBI's illustrated with sample practical demonstration of the proposed framework. Feedbacks have been revised and corrected and final corrected framework developed according to the business requirements of banks. Finally, after modification a researcher proposed IaaS framework adopted with private cloud deployment model for EBI's.

The different components of the proposed framework offer capabilities to address Scalability, Flexibility, Security and Cost Issues. Also the proposed framework may contribute to the banking industries a roadmap to adopt and implement Ethiopian Based Virtualized Infrastructure as a Service framework.

## 6.3 Recommendation

This study helps for the banking industries to select among available cloud deployment models and provides detail information for decision makers on the possible implementation Ethiopian Based Virtualized Infrastructure as a Service framework.

Hence, the researcher believes further researches have to be done for improvements. Some suggestions and future research direction are presented next.

- ✓ Future studies can carry out risks associated to migrate hardware asset from own DCs to a co-location facility of the private Ethiopian based Infrastructure as a Service provider.
- ✓ Future studies can carry out on analysis of Long term subscription fee may be more expensive than buying the hardware.
- ✓ Future studies can also be done the proposed framework and deployment model requires some changes to the current IT operations in the EBI's .A new approach need to implement like how to manage the IaaS and what need to be considered, changes to the operational processes in the service level agreement, capacity management and change management.
- ✓ Future studies can be done how to build trust management between Infrastructure Service provider and banks.
- ✓ Future studies can also be done on the security concerns of outsourcing infrastructure as a Service and encryption mechanisms to protect EBI's data.
- ✓ Future studies can also be done to select the best suitable Infrastructure as a Service framework for EBI's further assessment of different kinds of framework.

## 6.4 Limitation of the study

**Time constraints**

- ✓ Due to time constraints this thesis mainly focuses on Infrastructure as a Service framework of cloud computing services. However, other cloud computing service not considered in this study.
- ✓ The researcher considered only the banking industries for those implemented virtualization technologies in the DCs others organizations those implemented this technology not included in this study.
- ✓ The study not considered the legal aspects of the study

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## Appendix A

## INTERVIEW QUESTION

**1.** Which bank do you belong to?

1. What is your Position in your organization?
2. Has your organization implemented virtualization?
3. How many virtualizedservers do you have in your organization?
4. How many virtualized systems or application exist in your organizations?
5. How many System users in a virtualized environment?
6. What virtualization software has your organization implemented?
7. Which Virtualization Software products does your organization offer service to system users?
8. Your organization has various business reasons for virtualization. Which do you think most important reasons of your organization for virtualization?
9. What have you found to be the benefits of server virtualization for your organization?
10. What have you found to be the drawbacks of server virtualization foryour organization?
11. Please identify factors that would hinder adoption of server virtualization in your organizations?
12. What environmental factors were considered before making a final decision to adopt virtualization technologies at your organization?
13. Was technological readiness seen as a factor when you made the decision to adopt virtualization technologies?
14. What other organizational factors were considered before making a final decision to adopt virtualization technologies at your organization?
15. Do you believe virtualized data center solution can cause unnecessary complication for the bank and system administrators? Yes/ No Why?
16. Did you see complexity of the virtualization technologies at your organization process as a challenge?
17. Virtualization is current associated with a lot of challenges in different areas. In your organization what do you think the challenges of virtualization and there are for

instance organizational, technical and business challenges. How does your organization tackle these technical challenges?

18. Do you believe the banking industry should follow the traditional data center infrastructure or should run with virtualized technology? Yes/ No Why?
19. Do you think adopting virtualization technologies at your organization has given relative advantage over its competitors?
20. Does your organization have any plan towards outsourcing infrastructure? Yes/ No Why?
21. What is your suggestion in formulating a new paradigm which virtualization services do you expect to your organization become important in the years to come?
22. Do you have standard and legal framework or policy guideline for new technological infrastructure implementation? To what extent its functional level? Yes/ No?

# Appendix B

## Proposed Framework Evaluation Survey

## Addis Ababa University

## College of Natural Science

## Department of Information Science

Dear Sir or Madam:

In partial fulfillment of the requirements for the Degree of Master of Science in Information Science, I am undertaking a research on "**A Framework of Virtualized Infrastructure as a Service for Ethiopian Banking Industry** "at Addis Ababa University. Based on the individual discussions, I have amended the proposed framework and accordingly prepared this questionnaire. The objective of the questionnaire is to evaluate the proposed framework with respect to its comprehensiveness, clarity, completeness, correctness, and applicability.

This research is believed to produce results that can improve the EBI's resource utilization. Thank you for your dedication to provide your genuine feedback regarding the proposed framework.

Thank you again!

Tigist Yegremachew

**General**

1. The proposed framework is comprehensive in terms of coverage

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

2. The organization and presentation of the framework is suitable for EBI's

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

3. The objective of the framework is clear

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

4. The content of the proposed framework is complete

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

**Regarding the content of the framework**

5. The content of the proposed framework is relevant

- Strongly Disagree
- Disagree

- Neutral
- Agree
- Strongly Agree

6. The content of the proposed framework is clear.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

7. The content of the proposed framework is Scalable.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

**Regarding utility and applicability of the framework**

8 . The proposed framework is easy to use

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

9. The proposed framework is easy to be applicable.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

10 . The applicability of the proposed framework can improve Resource utilization, scalability , flexibility and reduce internal operational complexity

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

11. The implementation of the proposed framework fits with the organization problems

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree