ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

Department of Computing

Msc Information System Thesis

Title:-Designing of Everything as a Service (XaaS) Cloud-Computing framework for Ethiopian e-Government Services The Case Of Oromia Regional State Datacenters and Services

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September 25, 2016

Candidates Declarations

I hereby declare that this research project entitled “Adoption of Everything as a Service (XaaS) cloud computing framework for Ethiopian e-Government Services In Case Of Oromia Regional States Datacenters and Services” in partial fulfillment of the requirement for the award of the degree of master of science in Information system is an authentic record of my own work carried out from April 10, 2015 to June 8, 2016. The matter embodied in this research has not been submitted for the award of any other degree or diploma. All the relevant sources of information used in this research have been duly acknowledged.

Student Name:- Kedir Elka

Signature:- _____

Date: - _____

This is to certify that the above statement made by the candidate is correct to the best of my knowledge and belief. This research project has submitted for examination with my approval.

Advisor :-**Manoj V.N.V (PhD)**

Signature: - _____

Date: - _____

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Kedir Elka

September 25, 2016

Abstract

Public sectors and government agencies delivering e-government services should look for better vehicles to decrease IT budgets, and at the same time provide agile IT services to organizations and citizens. The paradigm of cloud computing, which has been recently introduced and developed, offers means for public managers and government executives to address issues of budget constraints and agility of service. Literature review shows that cloud computing deployment models such as private cloud, public cloud, hybrid cloud and cloud computing services such as Infrastructure as a Service ,Platform as a Service and Software as a Service were being defined and implemented in the industry. If adopted and implemented in developing economy like Ethiopia, these cloud architecture and services will benefit in lowering ICT infrastructure costs and acquire new ways to manage Data Center resources, applications developed and resources to develop software's to deliver e-government services to the public.

In this research project, great efforts have been made to adopt everything as a service XaaS of three vendors. Cisco IaaS cloud architecture for Ethiopian government Data Center particularly in Oromia Regional State Datacenters is adopted. Software as a service of Intel vendors is also adopted for Oromia Regional State datacenter application usage. Platform as a service is also adopted from Oracle cloud providers which enable Regional software development tools accessible simply from the vendors. The adopted architecture is based on the already existing government private cloud (Woredanet) and used to provide G2G (Government –to-Government) application with minimum cost for storage within government Data Centers.

Using open source virtualization software's XenServer 6.5 and Xencenter, we have tested the adopted infrastructure as a service is in area of small Local Area Network. The Software as a service and Platform as a service is also depends on the Infrastructure adopted and simple to experiment. We have analyzed the results of our testing that it can be scale up to WAN (Wide Area Network) like woredanet. If the Xencenter client application is installed on all of the woreda/district desktop computers that are connected to Oromia Regional Data Center, they can share resources of Data Center servers being at a remote location.

We recommend, therefore, that researchers give attention to these areas of cloud services both in private and public cloud deployment models. The future research should also focus on the bandwidth conception of XaaS in case of Ethiopian e.government and the security of XaaS.

Keywords: Cloud Computing, XaaS, E-Government, Private Cloud, Public Cloud

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Abbreviations

ADSL: Asynchronous Digital Subscriber Line

BPR: Business Process Re-engineering

B2B: Business to business

BPaaS: Business process as a service

CPU: Central Processing Unit

CSP: Cloud Service Provider

CLI: Command-line interface

CRM: Customer Relationship Management

CSA: Cloud Service Automation

DNS: Domain Name System

DRaaS: Disaster recovery-as-a-service

EICTDA: Ethiopia Information Communication Technology Development Agency

Etc: Ethio Telecom

FC: Fiber Channel

FCoE: Fiber Channel over Ethernet

G2B: Government to Business

G2C: Government to Consumer

G2G: Government to government

GUI: Graphical User Interface

HBA: Host Bus Adapter

IaaS: Infrastructure as a Service

IEEE: Institute of Electronics and Electrical Engineers

ISP: Internet Service Provider

IDS: Intrusion Detection System

IPS: Intrusion Prevention System

ISV: Independent software vendors

ITSC: Information Technology Services Centre

J2EE: Java Plat Form Enterprise Edition

MCIT: Ministry of Communication and Information Technology

NDC: National Data Center

NIST: National Institute and Standard Technology

NASSCOM: National Association of Software and Services Companies

NaaS: Network-as-a-service

OSS: Operational support services

PaaS: Platform as a Service

QoS: Quality of Service

RDC: Regional Data Center

RIP: Real Internet Protocol

SaaS: Software as a Service

SMB: Server Massage Block

SAN: Storage Area Network

SLA: Service Level Agreement

SNMP: Simple Network Management Protocol

SDPRP: Poverty Reduction Program

UDP: User Datagram Protocol

UCS: Unified Computing System

VEM: Virtual Ethernet Switch

VIP: Virtual Internet Protocol

VLAN: Virtual LAN

VM: Virtual Machine

VPN: Virtual Private Network

VSAT: Very Small Aperture Terminal

ZTE: Zhongxing Telecom Corporation

CHAPTER ONE

1. Introduction

1.1 Background

Governments are in realizing the potential benefits of the Information Technology to provide e-services. E-services are delivering cost-effective services, which can drive the growth of the economy and government productivity. Cloud computing is a talented technology model that is changing the way public sector organizations consume Information and Communications Technology (ICT), and how they deploy and deliver services to stakeholders. Cloud computing provides a new service consumption and delivery model inspired by Consumer Internet Services. It drives down costs and accelerates cost reduction benefits. In addition, cloud architectures can benefit governments to reduce duplicate efforts and increase effective utilization of resources [1]. It is also indicated in [2] that E-Governance with cloud computing offers integration management with automated problem resolution, manages security end to end, and helps budget based on actual usage of data.

The flow of information is essential for effective governance and managing the day-to-day business of government services for the citizens. E-Government creates opportunities to reduce the costs of providing information and services to the public. It is the use of Information and Communication Technology that have the ability to transform relations with citizens, businesses, and different levels of government. In an e-government implementation approach, ICT can serve a variety of different customers: citizens, businesses etc by empowering them through access to information. Some of the benefits of e-government services are - less corruption, increased transparency, greater convenience, revenue growth, and cost reductions. Some of e-government applications fall under the following categories [3].

- ***G2G*** *(Government to Government):-Administration, Inter-government enterprise, Control, monitor and distribution.*
- ***G2C*** *(Government to Consumer):- Registration/Land/Revenue Services, Hospital services, Agricultural services.*
- ***G2B*** *(Government to Business) :Tenders (e-tenders),Contract Management ,Tax.* [3].

The goal of **e-governance** is to Expand services for stakeholders (Governments, citizens, businesses), Improve internal operations, Increase collaboration and access to information.

All these e-government applications rely on the available infrastructure at the data center, software applications which enhance government eservices, and platform applications, which is used to develop these applications. All of the government services are an essential corporate asset that connects all servers, applications and storage services.

Therefore, these services are a key component that needs to be planned and managed carefully to meet the growing performance demands of users and applications.

With its emphasis on consolidation, virtualization, and automation, cloud computing has emerged as an important strategy for achieving e-government goals and managing data centers and applications. As it is described in [4], governments that adopt cloud-computing strategy believe that "If the goal of e-Governance is to be achieved, it can do so by leveraging cloud everything as a service without having to purchase significant hardware and software lowering both time and cost barrier in service delivery."

1.2 E-government Services in Ethiopia

Ethiopian Government has recognized the power of ICT in national development plan and had launched e-government initiatives in 1997 E.C [4]. One of the e-government initiatives is establishing VPN called "Woredanet ICT Network" in which all public sectors in the country are to be connected to get e-Services from National Data Center. The objectives of the woredanet is to provide ICT services such as video conferencing, directory services, mail services, voice services, and Internet connectivity to the federal-level, Regional-level and woreda-level government entities. The service is also to build a transparent & accountable government system and increase citizen participation in the government. Beneficiaries of the services are the public sectors, business organizations and community .The long term plan of the government is to ensure e-governance in which the following components of e-government will be justified. These components are: G2G (Government to Government), G2B (Government to Business) and G2C (Government to Citizen).E-government (electronic Government) is defined as the service delivery model of a government to its customers in which traditional delivery mode is substituted by online services to ensure efficiency in governance and public sectors. Based on this initiative, there are 1 National Data Center, 9 Regional Data Centers in the country. The National Data Center is connected to the Regional Data Centers and to all woredas that have woredanet ICT Network in the country. Currently, over 630 woredas (districts) are connected; some government ministries and some Regional bureaus that are connected to the woredanet are getting internet and video conferencing services. In addition, Regional Data Centers are established in each Regional State. These Data centers are providing ICT services such as video conferencing, directory, messaging, and VoIP and Internet at the federal, Regional and lowest level of government throughout the country. [4]

Federal government ministries and Regional Bureaus have conducted BPR (Business Process Reengineering) study of their respective businesses and developed MIS applications since 2000 E.C. As an example, in Oromia about 22 Regional bureaus developed MIS applications after BPR study, where each of them developed sector specific applications and databases. Some of the Bureaus have developed specific applications like Oromia Revenues authority SIGTAS, Oromia Finance and economic development Bureaus IBX/IFMISS, Oromia Healthy Bureaus

HMIS, Oromia Court , Court Management System, Oromia Education Bureaus, Education Management Information System, Oromia Good Governance and Civil Service Bureaus. [4]

All of them require installation, patching, configuration, deployment, independent storage and computing power (Server, CPU, and Memory) which is very expensive to purchase for each of these Regional bureaus. If we imagine for the remaining 8 Regional states the same scenario exists to store application and data of their respective bureau. As the need of automating the manual business process increases within public sectors of the country, it requires complicated installation and configuration and huge amount of storage space and computing power. [4]

By considering the above limitations of the existing service delivery, the main focus of this research is on issues that are appropriate to deliver application and data center services through cost effective way. Therefore, this research attempts to seek a solution by adopting Cloud XaaS Architecture for Ethiopian e-Government Services.

1.3 The Ethiopian Government Cloud (WoredaNet)

Woredanet is a terrestrial and satellite-based network whose primary objective is to provide ICT services such as video conferencing, directory services, mail services, voice services, and Internet connectivity to the federal-level, Regional-level and woreda-level government entities. From conception, the Woredanet was established to leverage its infrastructure to establish a three-tier structure for the provision of government based quality ICT service to the public sector driven by user requirements. This was to be achieved by harmonizing efforts undertaken by other government institutions in terms of ICT capacity building or service delivery by use of and/or extension of the Woredanet infrastructure. [4]

The Woredanet ICT Network is instituted as an infrastructure frame (Skeleton) that goes in line with the FDRE's Federal and Regional government's hierarchy. The upgrading works of this system are designed to cover the government's administrative, legislative and executive organs hierarchical structure. [4]

Figure 1.1 Below depicts architectures of Ethiopian Government National Network

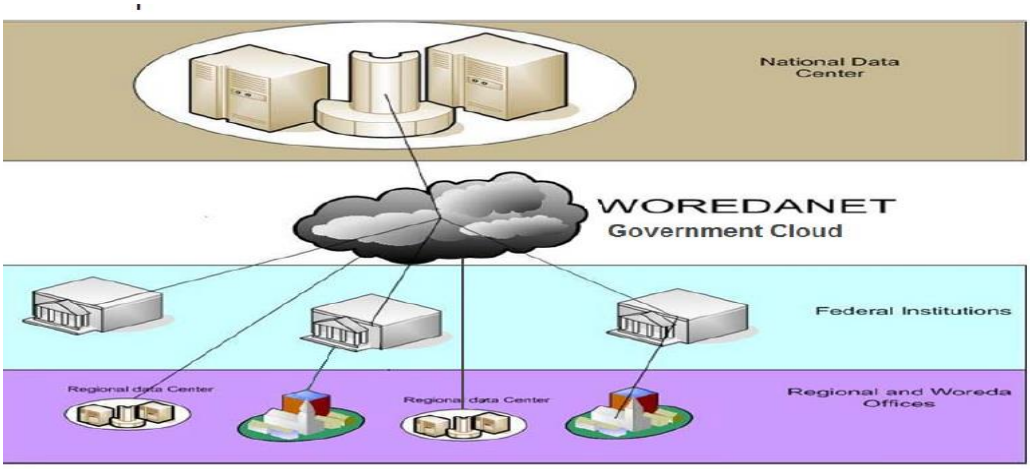


Figure 1.1 Ethiopian Government National Information Network Architecture [4]

As shown in figure 1.1 there is one National Data Center, NDC, with high-speed Fiber optic Network connectivity with the Ethiopian Telecom Broad band Metro Network (BBMN). There are 13 ministries, 19 agencies, 9 Regional Data Centers and some of woredas/districts are all connected via a Terrestrial connectivity ADSL (Asynchronous Digital Subscriber Line) to the ETC BBMN. The rest of the woredas are connected via satellite VSAT (Very Small Aperture Terminals). NDC has redundant and failover systems by design.

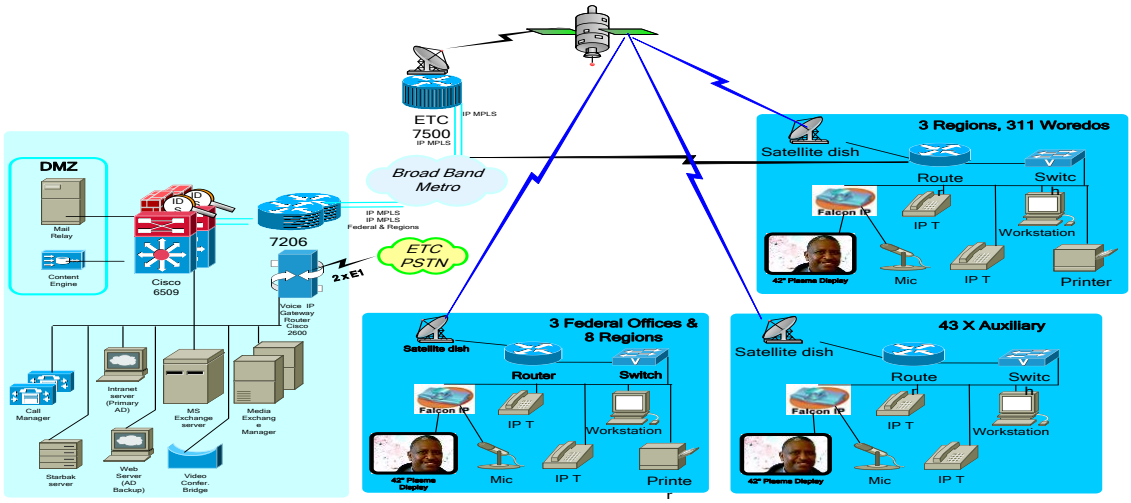


Figure.1.2 The Woredanet Architecture as it follows the Government Structure [5]

1.4 G2G Services in Ethiopia

The Woredanet is capable of delivering the following core services to all of the federal, Regional and Woreda sites that are included within its scope [5]:

Web Service: - To provide wider access to content available on the Internet for education, health, agriculture and governance by civil servants. Such service will contribute in the bridging the digital divide currently experienced between unequal distribution of Web access between urban and rural and between densely populated towns and thinly populated remote areas.

Voice over IP (IP-Telephony) Service:-To establish a common and singular voice over IP (Internet Protocol) communication infrastructure between Federal, Regional, and Woreda sites which can be stated to be non-existent at the present. This particular service is expected to contribute largely to the increase of the tele-density of the country by providing an aggregated telephone access service especially to remote woredas without having to traverse the traditional telephone exchanges.

Directory Service: -To establish a government wide catalogue of digital resources for managing of government folders, files, users, computers, and enforcing of a coherent usage policy in the sharing of such resources. The directory service can greatly impact the alignment of government goals from a top down approach as well as across lateral approach by the design and implementation of policy across a network such as Woredanet.

Messaging: - It is an email and chat messages within the government intranet (woredanet) based on web service technology. It is based on web service protocols used for any other web services but within intranet email applications. It is structured and secured messaging service following the government hierarchical structure from federal, to Regional and to woreda. It is a consistent and true collaboration environment, whereby free flow of mail messages can take place between governments organizations connected to woredanet. As an example, contact details of a specific resource at a woreda, e.g. an email address owertiyo@oromiya.gov.et can be published, and common experiences can be posted and shared among the different levels of government.

Video Conferencing: - To reduce distance, time, and cost and to substitute the value of face-to-face meeting by use of IP based Videoconferencing devices as tools for conducting meetings. The value of such a tool is not only for holding up a one to one meetings but also in conducting group meetings and broadcasting recorded sessions, programs or television content to the remote woredas.

Web based Government Applications: - .In order to obtain maximum benefits from opportunities provided by ICT, appropriate ICT content and application is developed and tailored to user needs. The government is committed to the development of locally relevant ICT content and application consistent with specific sector business process.

In this line, the Oromia National Regional government is determined to develop and implement appropriate sector based content and application in priority areas but spanning over 22(twenty two) Regional bureaus. These public sectors have studied the BPR of their sector specific business and are connected to woredanet. A total of 45 applications with their respective data base and Regional portal were developed and deployed in Oromia Regional Data Center.

The developed MIS (Management Information System) are based on web service technology and accessed only within the government intranet (woredanet) through browsers. There is also a bureau specific application developed for the purpose of specific task, which is installed on standalone computer.

1.5 XaaS (IaaS, PaaS and SaaS) Technological Attempts in Ethiopia

Shared hosting is the prominent hosting option for most businesses and government organizations in Ethiopia. Most business and government institutions host their web-based application on EthioTelecom servers. The principle of XaaS hosting option comes from the fact that EthioTelecom is sharing the resources of a single server with many other users. This sharing option extends to email systems, portals and some web based

applications. Potential breaches or performance problems on websites outside of our control can take down the server and leave our website offline for prolonged periods [5].

1.6 Oromia Regional State Woredanet

The same scenarios available in Oromia Regional State. Many services available in Oromia Regional State like portal, mail services are available for the public organizations through woredanet. The Region develops MIS applications for 21 Regional bureaus and deploys it on woredanet VPN. All these services are available through woredanet VPN that deployed at Oromia data center and given by three redundant data centers which contains different hardware's (router, switch, server, UPS)

From these, everything as a service XaaS (every ting as a service) is not implemented in Ethiopia and Oromia Regional State Currently. Even if many researchers have done many researches regarding cloud computing it was not implemented in Ethiopia.

1.7 Statement of the Problem

Oromia Regional State has three data centers which are built with any rules and regulations for the purpose of redundancy. This data centers contains many equipments like Servers, computers, air Conditioners, Storage Medias, CCTV Cameras, Routers, Switches, Racks and all of these materials consume power which costs the Regional State more money. If we imagine servers located in three data centers, it is about wastage of money in the Region. The above Scenarios works for all 9 Regional State of the country, Ethiopia.

The Oromia Regional State also developed money applications by outsourcing and in house. The application developed in Oromia Regional State needs huge amount of training and effort for development and configurations. Licensing and patching of these applications needs more many, which the Region cannot afford. Instead of buying application software's, and facing the complexity of buying and maintaining of hardware and software for the provisioning of platform applications, XaaS cloud architecture and virtualization technology can serve for better enhancement of the organizations capability of customer services.[Source: Interviews]

Software used in the Region is also used without any license and legal background, which brings a consequence of many problems. Most of the time this software freely available from the market with minimum cost. Because of no any patching and updates they are attacked by viruses and files of the users are lost. To solve this problems the cloud computing services has to be implemented. Security of the adopted cloud is also one of the major issues to be considered through the work. [Source: Interviews]

To seek a solution to these problems Cloud infrastructure, software and platform services of XaaS architectures has to be adopted.

This research is done to answer the following research question.

How can we provide XaaS cloud services using few Data Centers, software's and platform in Ethiopia particularly in Oromia by developing suitable Framework? The research also answers the following questions in detail.

- ***What is the possible Framework for XaaS cloud service technologies available, their implementation for e-Government services and their potential and associated advantages and challenges?***
  - ***What is the possible IaaS Framework for Woredanet VPN particularly Oromia Regional State Datacenters?***
  - ***What is the possible SaaS Framework for Woredanet VPN particularly Oromia Regional State Datacenters?***
  - ***What is the possible PaaS Framework for Woredanet VPN particularly Oromia Regional State Datacenters?***

1.8 Objectives of the Research

General Objective

The main objective of the study is to design a framework for XaaS cloud service architecture in Woredanet of Ethiopian government to enhance e-Government services for the society.

Specific Objectives

To achieve the general objective the specific objectives of this research work are as listed below.

- To assess the existing infrastructure in Oromia Regional State Data center at particular and Woredanet VPN in general.
- To assess and compare the existing Oromia regional data Center architecture with XaaS cloud architecture requirements
- To review and select the XaaS cloud components(IaaS, PaaS and SaaS) architecture that is appropriate to adopt in oromia Regional state data centers
- To Review literature on policies and parameters to implement XaaS cloud service.
- To define system and users requirements.
- To produce a framework that helps to adopt XaaS cloud services in oromia regional state Data centers.
- To conduct experiments using open source tools on the adopted architecture in one of the Oromia Regional Data Centers

1.9 Methodology of the Study

Both qualitative and quantitative methods will be used to conduct the study. NDC (National Data Center) and Regional Data Centers will be conducted under the study. Applications software's and system software's that runs on Woredanet VPN will be conducted. National data center and some Regional bureaus and sample woredas that are connected to woredanet VPN are also part of the study. The following methodologies will be used in the research:

1.9.10 Literature Review

Literatures on traditional data centers, cloud data centers, cloud computing benefits, XaaS cloud service providers, XaaS cloud services architectures and platforms will be reviewed. The existing XaaS cloud service architectures, technologies and how different countries used for e-Government services will be reviewed. The literatures on ICT/e-government policy, Information exchange standards and regulations in Ethiopia will be reviewed. In addition to these, books and articles of related field is reviewed.

1.9.1 Study Population and Sampling Method

Study population and sampling method are used in this research. Random sampling method is used for questionnaires that distributed to the targeted group.

1.9.2 Data Source and Data Collection

Data source is creating correct and exact questionnaires for selected and targeted customers. These questionnaires and interviews must be to the right person for successful research.

- **Questionnaires**

The questionnaires are also prepared for Oromia Regional State ICT agency directors and experts. Regional Bureaus ICT experts are also one of the interviewers ethio telecom and national data center is also target group them to be interview.

- **Interview**

Interviews are made with Oromia Regional State ICT agency heads, experts and concerned peoples. National datacenter and Ethiotelecom experts are also part of these interviews.

- **Observations**

The existing service delivery of application and platform software are observed in Oromia Regional State ICT agency and National Data centers. Oromia Regional State ICT agency data center is also observed. The observation will be the physical infrastructures like server, router, switches and other data center equipments. What are the application hosted and used by the organizations is also one part of the observations.

1.9.3 Data Analysis and Interpretations

Data collected will be analyzed using comparative analysis. The existing XaaS cloud service architecture and technologies reviewed in the literatures will be compared with the result of data analysis. The analysis of the quantitative data is analyzed and interpreted with number based calculations and the qualitative data is interpreted and analyzed with text or method based

1.9.11 Design Procedures

Implementation and testing of the Framework for XaaS cloud architecture is carried out by experimenting each of XaaS components. From the bottom of the framework that is IaaS is tested and approved for the real implementations. Then on top of IaaS, PaaS is tested and implemented. Finally SaaS for applications available on the cloud is kept on PaaS.

1.9.4 Tools Used

In this research we have experimented on our prototype by using citrix XenServer 6.5. XenServer 6.5 is the complete server virtualization platform from Citrix. The XenServer package contains all you need to create and manage a deployment of virtual x86 computers running on Xen, the open-source paravirtualizing hypervisor with near-native performance. XenServer is optimized for both Windows and Linux virtual servers. XenServer runs directly on server hardware without requiring an underlying operating system, which results in an efficient and scalable system. XenServer works by abstracting elements from the physical machine (such as hard drives, resources and ports) and allocating them to the virtual machines running on it. A virtual machine (VM) is a computer composed entirely of software that can run its own operating system and applications as if it were a physical computer. A VM behaves exactly like a physical computer and contains its own virtual (software-based) CPU, RAM, hard disk and network interface card (NIC). XenServer lets you create VMs, take VM disk snapshots and manage VM workloads.

Benefits of Using XenServer:- Using XenServer reduces costs, Reducing the number of separate disk images that need to be managed, Allowing for easy integration with existing networking and storage infrastructures, Allowing you to schedule zero downtime maintenance by using XenMotion to live migrate VMs between XenServer hosts. Increasing availability of VMs by using High Availability to configure policies that restart VMs on another XenServer host if one fails, Increasing portability of VM images, as one VM image will work on a range of deployment infrastructures.

1.9.12 Testing Procedure

I try to test the adopted framework using Xenserver virtualization tools. The testing is performed on LAN environment using routers, switches, computers and cables. Virtualizing virtual machine, storage repository configuration and computing resource configuration is the major jobs done.

1.10 Scope of the study

The scope of this thesis is also limited to only adoptions of XaaS components like SaaS, PaaS and IaaS. In case of IaaS it is also limited to Memory, CPU and Storage of the Infrastructures.

1.11 Limitations

The limitations for this research is tools used for implementation is not fully free. Literatures related to government services in Ethiopia especially woredanet is not available on internet.

1.12 Delimitations

The delimitation of the study is that the framework that is going to be produced may not work for public cloud because some government resources may not be exposed to public cloud. In these research areas like data as a service, network as a service and bandwidth as a service is not included.

1.13 Thesis organizations

The Organizations of this thesis depends on the standard thesis writing formats. Each Section separated by chapters which talks about specific area. The organizations of the papers are as follows:-

- **Chapter one:** - discusses about Introductions, Objectives, and Problem of statements.
  Under this chapter major topics like e.government, the Ethiopia cloud services, technology attempt Ethiopia and problem of statement is discussed.,
- **Chapter Two: -** discusses about Literature Reviews.
  Under this chapter literature reviews and related work is discussed. The concept of XaaS discussed in detail. E.government cloud and legal frame work in Ethiopia is discussed. Cloud adoption in different countries and related work in different universities is also included.
- **Chapter Three:** - discusses about Cloud Computing Assessments and Findings in Ethiopia.
  Questionnaires and interviews of different target group is discussed and analysis of the result is presented as graph.
- **Chapter Four:-** discusses About Implementations of the Findings and designing the performance of XaaS
  This chapter explains about Different parameters of framework selection. Findings of the research is also presented in this chapter..
- **Chapter Five:-** discusses about Conclusion and Future Works
  Conclusion and future work of this research is available under this chapter

CHAPTER TWO

2. Literature Review

This chapter explains about the concepts and technologies related to cloud computing and research works related to adoption of cloud architecture for e-governments and other services are discussed. To make readers get our objectives we start with the general concept and go to the specific issues that focuses on characteristics of e-government services in a cloud and requirements of cloud XaaS architecture.

2.1 Overview of Cloud Computing

National Institute of Standards and Technology (NIST) defined Cloud computing as "Cloud computing is a model for enabling ubiquitous (ever-present), convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [6].When you store your photos online instead of on your home computer, or use webmail or a social networking site, you are using a "cloud computing" service. If you are an organization, and you want to use, for example, an online invoicing service instead of updating the in-house one you have been using for many years, that online invoicing service is a "cloud computing" service[7].

Cloud computing refers to the delivery of computing resources over the Internet. Instead of keeping data on your own hard drive or updating applications for your needs, you use a service over the Internet, at another location, to store your information or use its applications. Doing so may give rise to certain privacy implications [7].

2.1.1 Characteristics

The characteristics of cloud computing include on-demand self-service, broad network access, resource pooling, rapid elasticity and measured service. On-demand self-service means that customers (usually organizations) can request and manage their own computing resources. Broad network access allows services to be offered over the Internet or private networks. Pooled resources means that customers draw from a pool of computing resources, usually in remote data centers. Services can be scaled larger or smaller; and use of a service is measured and customers are billed accordingly [6].

2.1.2 Deployment of cloud services:

Cloud services are typically made available via a private cloud, community cloud, public cloud or hybrid cloud.

Public cloud: -are offered over the Internet and are owned and operated by a cloud provider. Some examples include services aimed at the general public, such as online photo storage services, e-mail services, or social networking sites. However, services for enterprises can also be offered in a public cloud.

Private cloud: - the cloud infrastructure is operated solely for a specific organization, and is managed by the organization or a third party.

Community cloud: - the service is shared by several organizations and made available only to those groups. The infrastructure may be owned and operated by the organizations or by a cloud service provider.

Hybrid cloud: -is a combination of different methods of resource pooling (for example, combining public and community clouds)[6].

2.2 Cloud Computing Service Models

The cloud computing service models are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). In Software as a Service model, a pre-made application, along with any required software, operating system, hardware, and network are provided. In PaaS, an operating system, hardware, and network are provided, and the customer installs or develops its own software and applications. The IaaS model provides just the hardware and network; the customer installs or develops its own operating systems, software and applications [6].

As shown in figure 2.1 Cloud Providers offer services that can be grouped into three categories [8].

Software as a Service (SaaS)

In this model, a complete application is offered to the customer, as a service on demand. A single instance of the service runs on the cloud & multiple end users are serviced. On the customers‟ side, there is no need for upfront investment in servers or software licenses, while for the provider, the costs are lowered, since only a single application needs to be hosted & maintained. Today SaaS is offered by companies such as Google, Salesforce, Microsoft, Zoho, etc [8].

Platform as a Service (PaaS)

Here, a layer of software or development environment is encapsulated & offered as a service, upon which other higher levels of service can be built. The customer has the freedom to build his own applications, which run on the provider's infrastructure. To meet manageability and scalability requirements of the applications, PaaS providers offer a predefined combination of OS and application servers, such as LAMP platform (Linux, Apache, MySql and PHP), restricted J2EE, Ruby etc. Google's App Engine, Force.com, etc are some of the popular PaaS examples [8].

Infrastructure as a Service (IaaS)

IaaS provides basic storage and computing capabilities as standardized services over the network. Servers, storage systems, networking equipment, data centre space etc. are pooled and made available to handle workloads. The

customer would typically deploy his own software on the infrastructure. Some common examples are Amazon, GoGrid, 3 Tera, etc [8].

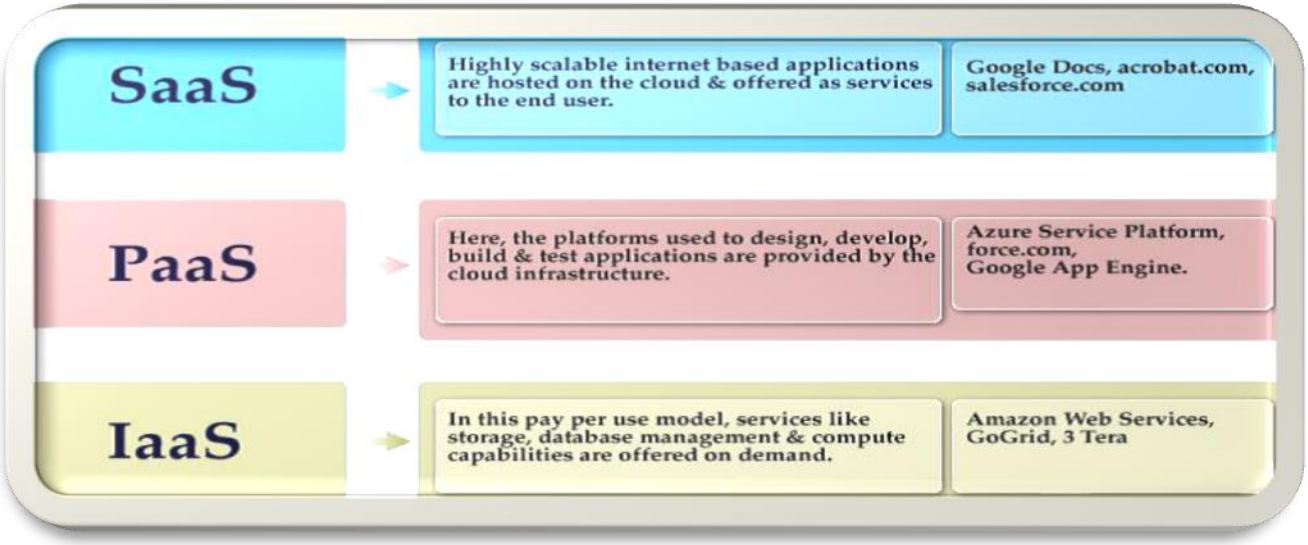


Figure. 2.1 The Cloud Computing Service Models [8].

2.3 XaaS Overview

Anything as a Service or X as a Service, usually the abbreviation XaaS is used. It is an umbrella term in informatics for a service-oriented approach to the management and use of information and communication technologies in the form of services. XaaS in practice: is just an umbrella term for various forms of the use of information and communication technologies as services, such as Software as a Service, Infrastructure as a Service, Platform as a Service, Communications as a Service, Network as a Service and Monitoring as a Service (MAAS). According to the Open Group, XaaS is the essence of Cloud Computing [9].

Anything-as-a-service, or XaaS, refers to the growing diversity of services available over the Internet via cloud computing as opposed to being provided locally, or on premises. Also known as everything-as-a-service, anything-as-a-service reflects the vast potential for on-demand cloud services and is already being heavily marketed and promoted by companies like VMware and HP.

Anything-as-a-service derives the "X" in its XaaS acronym as a result of being a catch-all term for everything from software-as-a-service (SaaS) to storage-as-a-service, desktop-as-a-service (DaaS), disaster recovery-as-a-service (DRaaS), network-as-a-service (NaaS), infrastructure-as-a-service (IaaS) and platform-as-a-service(PaaS), and even emerging services such as marketing-as-a-service and healthcare-as-a-service[9].

Software as a Service

SaaS is a rapidly growing market as indicated in recent reports that predict ongoing double digit growth. This rapid growth indicates that SaaS will soon become commonplace within every organization and hence it is important that buyers and users of technology understand what SaaS is and where it is suitable [10].

Characteristics of SaaS

Like other forms of Cloud Computing, it is important to ensure that solutions sold as SaaS in fact comply with generally accepted definitions of Cloud Computing.

Some defining characteristics of SaaS include:

- Web access to commercial software.
- Software is managed from a central location.
- Software delivered in a "one to many" model.
- Users not required handling software upgrades and patches.
- Application Programming Interfaces (APIs) allow for integration between different pieces of software.

Where SaaS Makes Sense

Cloud computing generally and SaaS in particular, is a rapidly growing method of delivering technology. That said, organizations considering a move to the Cloud would want to consider which applications they move to SaaS [10]. As such there are particular solutions we consider prime candidate for an initial move to SaaS:

- As per the "Vanilla" offerings, where the solution is largely undifferentiated. A good example of a vanilla offering would include email where many times competitors use the same software precisely because this fundamental technology is a requirement for doing business, but does not itself confer a competitive advantage.
- Applications where there is significant interplay between the organization and the outside world. For example, email newsletter campaign software.
- Applications that have a significant need for web or mobile access. An example would be mobile sales management software.
- Software that is only to be used for a short term need. An example would be collaboration software for a specific project.
- Software where demand spikes significantly, for example tax or billing software used once a month.

SaaS is widely accepted to have been introduced to the business world by the Sales force Customer Relationship Management (CRM) product. As one of the earliest entrants it is not surprising that CRM is the most popular SaaS

application area, however e-mail, financial management, customer service and expense management have also gotten good uptake via SaaS [10].

Where SaaS May Not be the Best Option

While SaaS is a very valuable tool, there are certain situations where we believe it is not the best option for software delivery. Examples where SaaS may not be appropriate include:

- Applications where extremely fast processing of real time data is required.
- Applications where legislation or other regulation does not permit data being hosted externally.
- Applications where an existing on-premise solution fulfills all of the organization's needs.

Platform as a Service

Platform as a Service (PaaS) brings the benefits that SaaS bought for applications, but over to the software development world. PaaS can be defined as a computing platform that allows the creation of web applications quickly and easily and without the complexity of buying and maintaining the software and infrastructure underneath it.

PaaS is analogous to SaaS except that, rather than being software delivered over the web, it is a platform for the creation of software, delivered over the web [10].

Characteristics of PaaS

There are a number of different takes on what constitutes PaaS but some basic characteristics include,

> Services to develop, test, deploy, host and maintain applications in the same integrated development environment [11]. All the varying services needed to fulfill the application development process.

- Web based user interface creation tools help to create, modify, test and deploy different UI scenarios.
- Multi-tenant architecture where multiple concurrent users utilize the same development application.
- Built in scalability of deployed software including load balancing and failover.
- Integration with web services and databases via common standards.
- Support for development team collaboration some PaaS solutions include project planning and communication tools.
- Tools to handle billing and subscription

Where PaaS Makes Sense

PaaS is especially useful in any situation where multiple developers will be working on a development project or where other external parties need to interact with the development process. As the case study below illustrates, it is proving invaluable for those who have an existing data source – for example sales information from a customer relationship management tool – and want to create applications, which leverage that data. Finally, PaaS is useful where developers wish to automate testing and deployment services.

The popularity of agile software development, a group of software development methodologies based on iterative and incremental development, will also increase the uptake of PaaS as it eases the difficulties around rapid development and iteration of software [11].

Where PaaS May Not be the Best Option

We contend that PaaS will become the predominant approach towards software development. The ability to automate processes, use pre-defined components and building blocks and deploy automatically to production will provide sufficient value to be highly persuasive [11]. That said, there are certain situations where PaaS may not be ideal, examples include:

- Where the application needs to be highly portable in terms of where it is hosted.
- Where proprietary languages or approaches would impact on the development process
- Where a proprietary language would hinder later moves to another provider – concerns are raised about vendor lock-in20
- Where application performance requires customization of the underlying hardware and software

Infrastructure as a Service

Infrastructure as a Service (IaaS) is a way of delivering Cloud Computing infrastructure, servers, storage, network and operating systems as an on-demand service. Rather than purchasing servers, software, datacenter space or network equipment, clients instead buy those resources as a fully outsourced service on demand [12].

By contrast, “Private Cloud” is infrastructure that emulates some of Cloud Computing features, like virtualization, but does so on a private network. Additionally, some hosting providers are beginning to offer a combination of traditional dedicated hosting alongside Public and/or Private Cloud networks. This combination approach is generally called “Hybrid Cloud.” [12].

Characteristics of IaaS

As with the two previous sections, SaaS and PaaS, IaaS is a rapidly developing field. That said there are some core characteristics which describe what IaaS is. IaaS is generally accepted to comply with the following:

- Resources are distributed as a service
- Allows for dynamic scaling
- Has a variable cost, utility pricing model
- Generally includes multiple users on a single piece of hardware

Where IaaS Makes Sense

IaaS makes sense in a number of situations and these are closely related to the benefits that Cloud Computing bring. Situations that are particularly suitable for Cloud infrastructure include:

- Where demand is very volatile – any time there are significant spikes and troughs in terms of demand on the infrastructure
- For new organizations without the capital to invest in hardware
- Where the organization is growing rapidly and scaling hardware would be problematic
- Where there is pressure on the organization to limit capital expenditure and to move to operating expenditure
- For specific line of business, trial or temporary infrastructural needs [12].

Where IaaS May Not be the Best Option

While IaaS provides massive advantages for situations where scalability and quick provisioning are beneficial, there are situations where its limitations may be problematic [12]. Examples of situations where we would advise caution with regards IaaS include:

- Where regulatory compliance makes the off shoring or outsourcing of data , storage and processing difficult
- Where the highest levels of performance are required, and on-premise or dedicated hosted infrastructure has the capacity to meet the organization's needs

2.4 Challenges of Adopting Cloud XaaS Architecture

The key challenges that create barriers between cloud computing and its adopters are privacy, interoperability, and reliability [13].

A. **Trust and Privacy: -** Nowadays cloud computing is completely moving towards virtualization. In a virtualized cloud environment, the cloud provider allocates a virtual machine (VM) for each client. The VM runs the client's applications and maintains virtual storage. The VM runs on the underlying provider's operating system. The advantage of virtualization in cloud computing is the isolation of VMs where the VM of each client is isolated from other clients, so that if any client's VM is infected with a virus or becomes malicious, it will not affect the other clients Under the same provider because they are residing on separate VMs.

B. **Interoperability**: - This is the ability of two or more systems work together in order to exchange information and use that exchanged information. Many public cloud networks are configured as closed systems and are not designed to interact with each other. The lack of integration between these networks makes it difficult for organizations to combine their IT systems in the cloud and realize productivity gains and cost savings. To overcome this challenge, industry standards must be developed to help cloud service providers design interoperable platforms and enable data portability. [13].

C. **Reliability: -** The challenge of reliability comes into the picture when a cloud provider delivers on-demand software as a service. The software needs to have a reliability quality factor so that users can access it under any network conditions (such as during slow network connections). [13].

2.5 Benefits of Adopting Cloud XaaS Architecture

Beside the challenges of cloud computing, there are numerous benefits of cloud computing that encourages business organizations to adopt IT solutions based on the cloud. The key benefits of adopting cloud computing are cost reduction, easy scalability and increased productivity [13].

A. **Cost Reduction: -** the usage of SaaS enables business organizations to minimize payment costs for IT resources and maximize business performance as well as profit. Clients are required to pay according to the use of resources. If clients need an application for a short period of time, it is useless to buy the application by paying the complete licensing cost. The solution based on cloud computing cuts down the cost of paying for the applications and resources that are not in use any more. [13].

B. **Easy Scalability**: - Cloud computing is a flexible model and provides on demand business scalability by using on-demand cloud services such as SaaS, PaaS or IaaS. Scalability is another aspect of cloud computing that can provide an advantage to business.

C. **Increased Productivity: -** In this rapid era of technology and innovations, business is growing rapidly. The demands of customers are increasing with high speed and they need the products more quickly with less time. In order to achieve these demands, business organizations around the globe need to communicate and collaborate by using IT resources such as collaborative applications and remote access web services.

Cloud computing provides these business demanded application on the cloud or internet. Users are able to access these applications at anytime and anywhere.

2.6 Comparison of XaaS with other IT services options

While Cloud Computing has been a major topic of interest and excitement in the IT world for several years now, many businesses are still only just be fitting to understand what it might mean for them and what impact it could have on their bottom line. Cloud based applications are able to support most forms of computer-based process in the current marketplace and offer great benefits for business. Part of this is because of the removal of the requirement to install and update new software every time there is a new release or update and this equates to significant savings, in terms of both time and money [14].The key practical differences between traditional computing environments and cloud computing are summarized in the table 2.1 below [14].

Characteristic	Cloud Computing	Traditional	Comments
Time before service can be accessed	Minutes/ Hours	Days/Weeks	Once the cloud computing environment is set up initially, you can gain access faster than in traditional environments where lead time is needed for installation, set-up, and configuration.
Capital Expenditure (CAPEX)	Pay-as-you-go, Variable	Upfront cost, Fixed	The pay-as-you-go model for cloud computing reduces or eliminates the large upfront costs incurred in procuring hardware and software and standing up traditional environments.
Economies of scale	Yes, for all organizations	For large organizations only	Cloud computing not only provides cost advantages in procurement of hardware and software, it also provides cost advantages from improved productivity. Traditionally, lessons learned from one environment must be duplicated in other environments but, with cloud computing, once the best practices are applied they benefit all consumers.
Multi-tenancy	Yes	Generally no, but can be found in application hosting	Multi-tenancy properly applied to cloud computing services allows providers to host multiple consumers effectively across shared resources. While it is more readily enabled in IaaS through the use of virtualization, PaaS and SaaS providers may need to undertake significant re-architecting of their platforms or applications to apply multi-tenancy to these elements as well as to infrastructure. Where this has not been undertaken, consumers may find that their platforms and applications are not as elastic or cost-effective as anticipated.
Scalability	Elastic and Automatic	Manual	Cloud computing resources can often be scaled up or down automatically, whereas human intervention is usually needed to add hardware and software in traditional environments.
Virtualized	Usually	Sometimes	Cloud computing environments are usually virtualized, whereas traditional environments include a mix of physical and virtualized infrastructure.

Table 2.1 practical difference between cloud computing and traditional environments [14].

2.7 Implementation of Cloud Computing for e-Government

E-Governance provides an automation of all government functionalities and enhances organizational efficiency and citizen participation. The effective e-governance involves e-governance requirements and components of the e-governance [15].

2.7.1 E-Governance Requirements

E-Governance provides a way to improve government work and make easy sharing of information with the citizens. For practical implementation of E-Governance, it is important to identify certain factors, which are going to play key role during deployment of E-Governance [15]. The e-governance requirements are divided into three parts:-

- **Government-to-Government:** The need of government-to-government functionality is fully related to administration, inter government control and monitor on the government. It focuses on the inter communication between two governments and other aspects of the government-to-government communication [15].
- **Government to Business:** Business organizations are important for any country and contributing substantially for the development. Government also keeps an eye on these organization for enforcing the policies, standards and accountability. Here it essentially required to automate government to business interaction such as tender management, contract management, tax payments etc. [15].
- **Government to Citizen:** Basically, the prime responsibility of any government is citizen service. Government to citizens interface is required to facilitate them basic emanates, proper education, health care and a quality life. A single window government solution could help to achieve citizens satisfaction required in E-Governance [15].

Figure 2.2 Typical requirements of e-governance [15].

2.7.2 Components of a typical E-Governance Application

Three-tier architecture for E-Governance is shown in figure 2.3 below. The architecture consists three layers of the system. In the data storage layer, proper schema for data storage has been defined for e-governance. It provides foundation for storage for data, which is coming from different processes and serves the request of the any process, which demands the data. Application layer works between user layer and data layer. It facilitates the connection between user process and data layer. The upper layer or user layer has a graphical User Interface for the user interaction with the system. In E-Governance system, a user can interact with the help of upper layer (GUI) and can get information from the system. The government officials and legislatures can update the information of the system with the help of upper layer .This architecture has the following advantages in context of E-Governance [15].

• **Heterogeneous System:** E-governance application support different platforms, different hardware and different working software. It integrates all these heterogeneous systems to fulfill the requirements of E-Governance.

• **Modifiability:** In 3-tier architecture, responsibility of each tier is fixed. Segregation of responsibilities makes it easy to modify and code at any tier.

• **Scalability to handle many clients:** Clients communicate with the system by using application layer. This application layer provides database connections to clients. The strength of client is deploying several servers on application layer.

• **Integrated Data Access:** Most of the applications use data from different sources. Application layer provide facility of managing the connection to database. Application is used to connect all these data sources.

Figure 2.3 explains the architecture of E-Governance with three layers:- User, application and Storage.

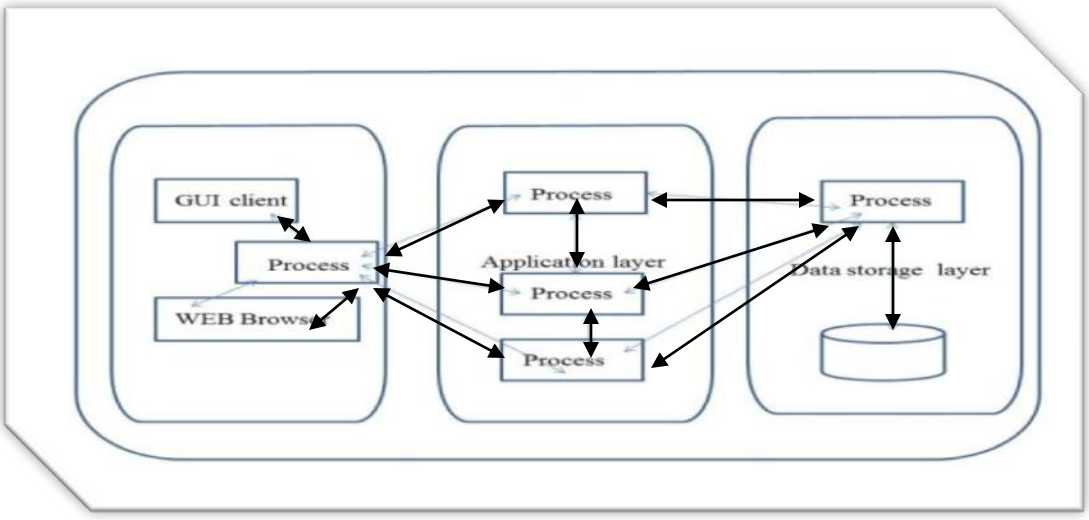


Figure 2.3: Typical architecture for an E-Governance application [15].

2.7.3 Layers of cloud computing for e-governance

Layers of cloud computing models for e-governance can be divided into three parts [15].

Infrastructure as a Service (IaaS): It provides infrastructure as a service including hardware and networks/storage requirements for data centers. For E-Governance applications common infrastructural requirement are 24x7 availability, uninterrupted power supply to data centers, proper bandwidth allocation. In the proposed model, the focus of application designer should be on usability and functionalities of E-Governance system.

Platform as a Service (PaaS): Cloud provides different type of platforms as a service such as OS provisioning, middleware support services, database support services and workflow management. In e-governance with cloud advantages departments can get resources whenever they need them as compared to traditional methods.

Software as a Service (SaaS): It provides all application requirement for success full implementation of E-Governance .For example , Suppose an E-Governance plan decides to extend their area at district level Than no software is required to purchase at district level but cloud provider will provide required software along with additional standards services such as employee management system, district management solutions; call center service etc. in this manner cloud can provide best solution as per requirement, Hence cloud reduces cost of E-Governance.

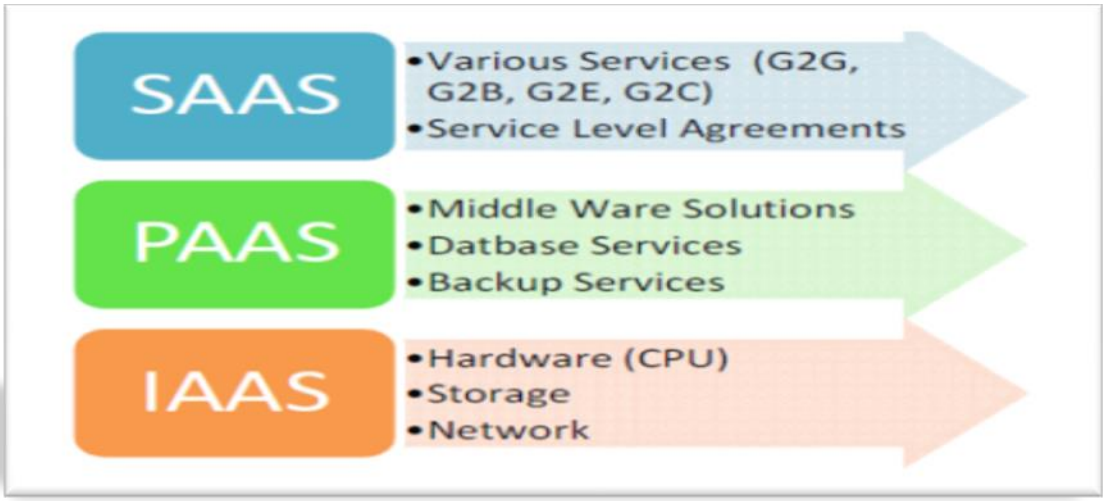


Figure 2.4: Layers of cloud computing for e-governance [15].

The above figure 2.4 is also the same for implementation of XaaS. It is simply putting the layers top of each other.

2.7.4 Cloud Vision for E-Governance

This section performs a selection of elements for the cloud, which is useful, for implementing the cloud based E-Governance [15].

Internet over Cloud: Most of services on internet are dependent on cloud 70% of the internet users are also using cloud in various applications.

Distributed Data Centers: Individual information systems are vulnerable to risks such as outside attacks, intruders, environmental risks etc. Distributed data centers provide protection from these types of threats. Distributed data centers facilitate the E-Governance application usage and management by providing support for communication and real time platform. Data is distributed among different centers so single ownership on data is eliminated and it provides more security to information related to citizens.

Data Center Operation: Main aim of Data center operations is to facilitate availability and continuity of services. Cloud computing uses cost effective hardware for setting data centers and the same data center can be shared in various E-Governance application. Use of same hardware setup is used for various e-government applications. It increases the resource utilization and provides scalability to the E-Governance system. On the basis of resource consumption, future plan could be built for e-governance applications.

Layer of cloud	Configuration of layers for e-governance	
Infrastructure as a Service (IaaS):	• Server hosting • Internet access • LAN/WAN • DNS	• Web servers • Storage • Data management • Computing hardware
Platform as a Service (PaaS):	• Knowledge management • Data mart	• Content management • Instrument and testing
Software as a Service (SaaS):	• Web applications • Meta data management • Portal services • Enterprise services • Workflow • Human management	• Human resource • Groupware • Collaboration • Digital asset management • Digital signature • Communication

Table 2.2: Configuration of layers of e-Governance [15].

The above table 2.2 is the same for XaaS framework. There is no difference simply putting the layers on top of each other.

2.7.5 Challenges of Traditional e-governance

Traditional e-governance faces different challenges as listed below [16].

- Resources cannot scale up and down with the demands that change over time. This may result in insufficient or redundant resources
- SW and HW have to be frequently upgraded and maintained which costs, time and money
- New SW licenses have to be purchased

- System should be available 24 hours a day and 7 days a week.
- Limited data storage and recovery
- Need to provide secure environment with authentication and access control
- Lack of accountability

2.7.6 Placement of e-Government Services in a Cloud

Before putting e-government services to cloud decisions have to be taken on which e-government services have to place in private cloud or public cloud. The following section discusses placement considerations and principles before deciding to put e-government services to clouds.

Placement Considerations

As indicated in [17], before putting e-government services in to clouds the following considerations have to be taken into account. Security and risk management, business requirement, leveraging common e-government services, economy of scale, rapid elasticity and presence of high bandwidth internet connectivity are among important factors to be considered before deciding to place e-government services to clouds.

Placement Principles

It is also indicated in [17], before putting e-government services in to clouds e-government services that are to be put in private clouds or in public clouds have to be differentiated. E-government services with classified data have to be put in to private cloud. These e-government services are to be deployed in government data centers. Examples of e-government services with classified data are those application and support services specific to government (HRMS and e-court). E-government services without classified data can be put in to public cloud. Examples of e-government services without classified data are those application and support services that can be put to public (e-mail and e-procurement).It is also indicated in [18] Cloud services such as PaaS (e.g Sharepoint) that is used to develop mission critical applications should not be put to public cloud.

2.7.7 Requirements of e-Government Services in a Cloud

Before putting e-government services in to clouds, the following core Infrastructures must be in place as indicated in [17].

- Data centers
- Facilities management
- Core network (government network connectivity & SAN)
- Virtualizations
- Automation
- Self-service portal
- IDS/IPS,
- load-balancing, DNS

2.8 Performance analysis of Cloud Computing

In this section we provide a comprehensive evaluation of the Amazon AWS technologies. We evaluate the performance of Amazon EC2 and storage services such as S3 and EBS. We also compare the Amazon AWS public cloud to the Fermi Cloud private cloud.[45].

2.8.1 Memory hierarchy performance

This section presents the memory benchmark results. They sufficed to run read and write benchmarks. The experiments for each instance were repeated three times. Memory bandwidth is a critical factor in scientific applications performance. Many Scientific applications like GAMESS, IMPACT-T and MILC are very sensitive to memory and width Amazon has not included the memory bandwidth of the instances. It has only listed their memory size. I also measure the memory band-width of each instance. [45].

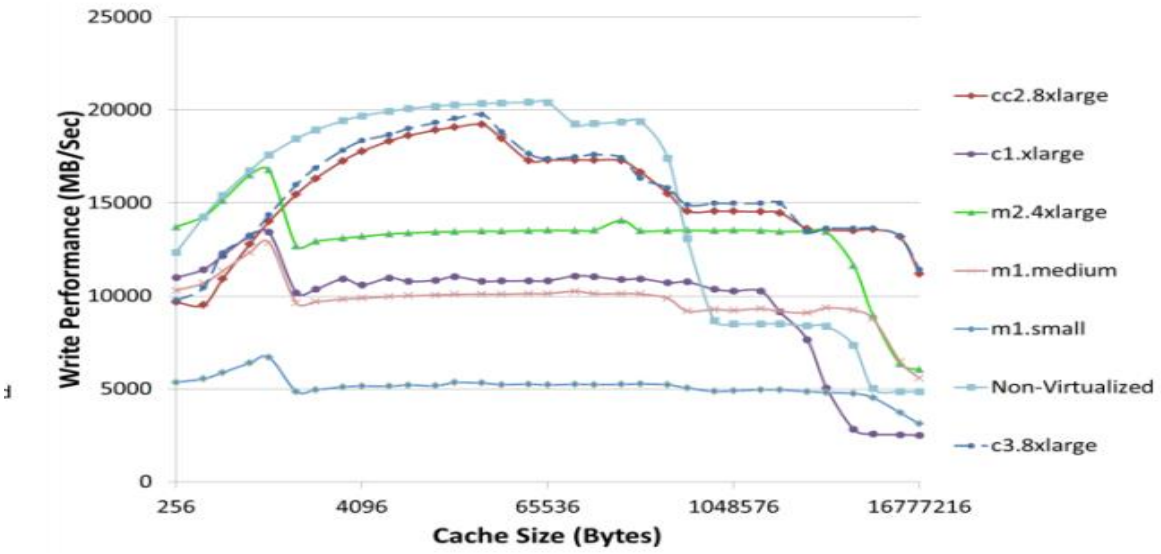


Figure 2.5:- Memory Performance.[45].

Result of figure 2.5 above shows that cache size and write performance for all instances are bending graph.

2.8.2 Network performance

They have run many experiments on network performance of Amazon cloud. The experiments test the network performance including bandwidth and latency. [45].

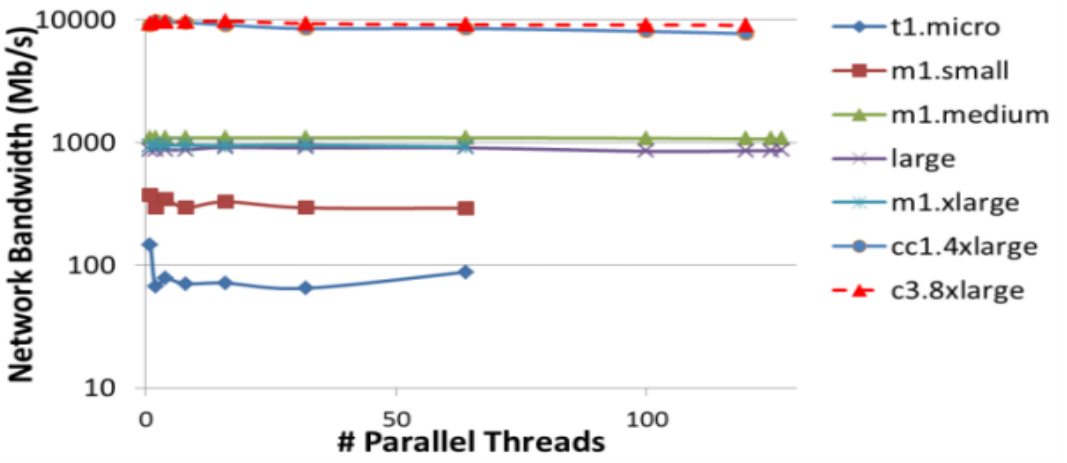


Figure 2.6:- Network Performance. [45].

From the figure 2.6 above the network performance of parallel threads and network bandwidth is the same for all types of instances.

2.8.3 Compute Performance

In this section, we evaluate the compute performance of EC2 instances. Figure below shows the compute performance of each instance using HPL as well as the ideal performance claimed by Amazon. It also shows the performance variance of instances. [45].

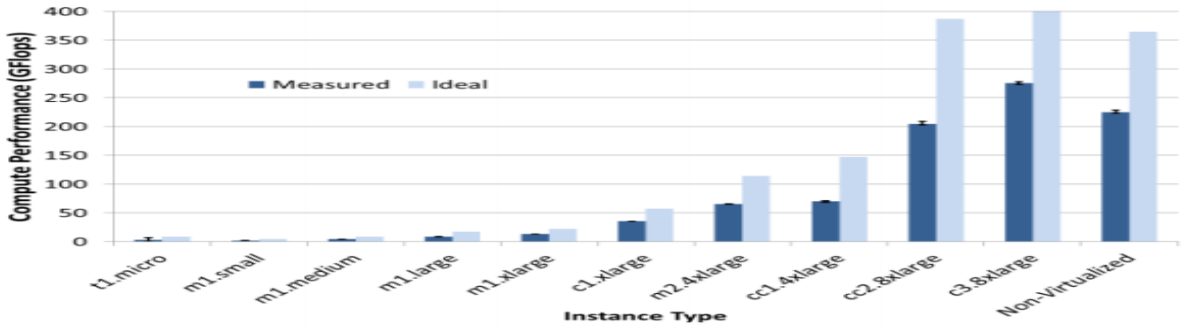


Figure 2.7:- Compute Performance. [45]

Form the figure 2.7 above the result shows that for instances of large the compute performance is better than micro and small instances.

2.8.4 Raw performance comparison. [45]

On both of the Clouds, they have chosen the instances that can achieve the highest performance on HPL applications. On EC2, they use c3.8xlarge instances that are enabled with Intel Xeon E5-2680 v2 (Ivy Bridge) Processors and a 10 Gigabits network adapter with SRIOV technology. On FermiCloud, each server machine is

enabled with 2 quad core 2.66 GHz Intel processors, and 8 port RAID Controller. On FermiCloud machines are backed by (16 Gigabits effective) Infiniband network adapters.[45].

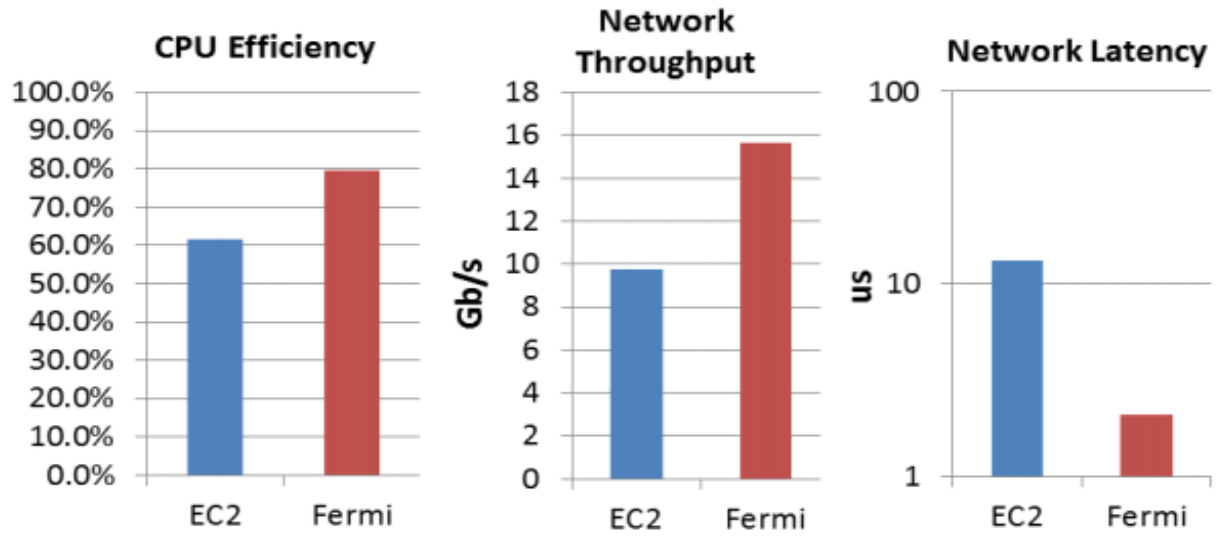


Figure 2.8:- Row Performance Comparison.[45].

From the figure 2.8 the result obtained is that for CPU efficiency and network throughput for EC2 and Fermi cloud computing provider the fermi is higher. For network latency EC2 is better.

2.8.5 Memory Cost. [45]

This section compares the cost of the memory on Amazon EC2 instances. Figure. 20 compares the cost of instances based on their memory capacity and bandwidth.[45].

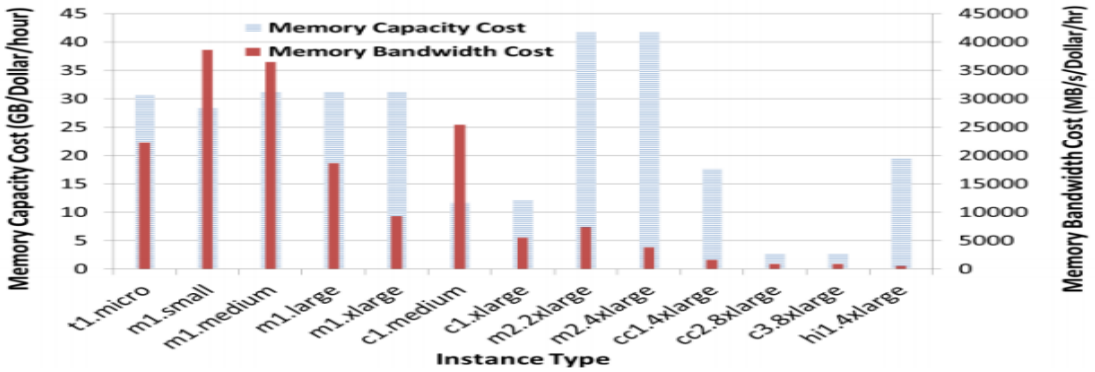


Figure 2.9 Memory capacity and memory bandwidth cost.[45].

The result of figure 2.9 shows that for instances of medium and micro the memory capacity cost is higher. For the large instances the memory capacity cost is small.

2.9 Overview of Cloud Hosting

a. Private Cloud Hosting

This hosting option is also known as Clustered Servers. For larger enterprises, there is a need to ensure consistent performance and reliability. This is usually achieved through a set of clustered servers, which share the load (load balancing) of the required performance. The content and applications are also mirrored across the cluster to ensure that performance is always maintained at an optimum level .This is more expensive but removes the single point of failure risk as, even if one of the servers breaks down, the rest of the servers keep running and delivering results of visits to the website or application. It's another advantage is, no external data security risk, has complete control feature so that corporate governance of data and application assured. This option is preferable for hosting G2G applications [21].

b. Public Cloud Hosting

Public Cloud Hosting is a large cluster of servers that provide all of our hosting requirements in an elastic manner, scaling up and down, as we need it in Response Percent to demand for our web applications or websites. It is generally paid for as a utility, meaning we only pay for what we use. Its limitation is that it is difficult to assess external data risks and corporate governance issues. Because the public cloud is such a large virtual space, there can be huge volumes of websites and web applications operating within it. If one of these goes wrong and starts demanding lots of resources, the cloud will adapt to fulfill its needs. This option is preferable for hosting B2B applications. The best known cloud service is Amazon EC2 web services [21].

Cloud Hosting		
Private Cloud Hosting	• Complete Control • Guaranteed Reliability through SLAs (if outsourced) • No Single point of failure • No external data security risk • Corporate Governance Assured	• Expensive • System admin skills essential unless the cluster is under a managed contract
Public Cloud Hosting	• Less Expensive • Fully managed by a third party, better reliability • No performance issues – it scales as needed	• So large that external factors may affect our site and may take a long time to resolve • Difficult to assess external data risks and corporate governance issues

Table 2.3: Summary of Cloud Hosting [21].

From the summary Table 2.3 [21], it can be concluded that cloud hosting option has tremendous advantages than traditional hosting options. E-government applications require corporate governance and have to be free from external data security risk. Therefore, from the cloud hosting options researchers in [21];[22] recommend private cloud hosting options for e-government applications.

2.10 Comparison of Cloud versus Grid Computing

Distributed Computing is a group of networked computers that work on a smaller portion of a large task simultaneously. This group can consist of any kind of computer including virtual servers from a cloud. Distributed Systems are open and scalable. The computers in the system can come and go and the distributed system server must assign the work and collect the output from the systems as they arrive and leave [23].

On the other hand Cloud Computing is a specialized form of Distributed Computing. In Cloud Computing the underlying resources, such as storage, processors, memory, are completely abstracted from the consumer. Therefore the vendor of the cloud service is responsible for the reliability, performance, scalability and security of the service. For the developer this is a big advantage. For the companies, this reduces capital expenditure. The disadvantages are the loss of control over the outsourced resources, latency, network and cloud integration issues [23].

Summary of comparison between grid computing and cloud computing is presented in table 2.4

	Personal Computers	Centralized Computing	Cloud Computing
Applications	Run by the user on their own computer, hard disk etc.,	Run for the user by their IT center on the IT center's central server.	Run for the user by a third party on their shared hardware.
Connections	Connect to local hardware.	Connect to LAN to IT datacenter.	Connected through Web to somewhere.
Pros	Everything is local. The user owns it and runs it as much as they want.	IT center owns it and runs it for the user. Local connectivity and user needs to know how to use the service.	Third party owns it and user pays by the usage. No worries about backup, storage, power usage or restore.
Cons	Users have to be at	Users use what they get.	Connectivity is an

	their PC to use it. Users responsible for the backup, power use and storage.	Users don't have control over the corporate decisions.	issue. Everything – data and tools are stored elsewhere. Users don't have control over security.
Example	Using PowerPoint 2007 on user's PC with Microsoft Office licensed software.	Microsoft Exchange Server in the company's IT center.	Using Facebook through a web interface – on hardware and software that user knows nothing about.
Analogy	Owning your own boat.	Renting a boat for a holiday.	Riding around on someone else's boat by paying for fuel and food.

Table 2.4 Grid Computing versus Cloud Comparison [23]

2.11 ICT Policies to Adopt XaaS Cloud Architecture in Ethiopia

ICT has become an integral part of Ethiopia's development programs over the last decade, following initial indifference to the development of the sector. The country faces a substantial gap between interest in the ICTs and the policy and regulatory instruments available to enable its development. ICT is one of the major components of the Sustainable Development and Poverty Reduction Program (SDPRP) of the Ethiopian government. The most consolidated and recent policy framework is the Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) that runs between 2005 and 2010. Five major initiatives were designed with regard to the ICT sector development in the PASDEP document. [24]

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

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

The broad ICT sector policy of the Ethiopian government that derives from PASDEP was developed in 2006 by the Ethiopian ICT Development Agency (EICTDA).One of the key areas where the policy aims to is "Promote the use of

ICT for modernizing the civil and public service to enhance its efficiency and effectiveness for service delivery, to promote good governance and reduce wastage of scarce resources". [24].

To achieve the above objectives, the Ethiopian Ministry of Communication and Information Technology (MCIT) has undertaken a number of e-Government initiatives to improve the internal efficiencies within the government organizations and improve the access to government services for the general public. These initiatives are explained as follows [24].

2.12 ICT initiatives in Ethiopia

The major initiatives can be divided into four major categories: - ***Infrastructure***(backbone of ICT activities, connectivity, networking). ***Applications(***automation, online informational and transactional services, common application like IFMIS, HRMIS, Portals). ***Standards & Guidelines, policies, strategies***. ***Human Resource Development***, ICT skill in specialized and general level [25].

a. Infrastructure

Ethiopia has been building its fiber backbone. A national backbone fanning out from the capital Addis Ababa in seven directions has been under construction as a result of a massive investment through a vendor financing loan agreement with China's Zhongxing Telecom Corporation (ZTE) .The 10,000km fiber network connects 78 towns with a capacity of STM-1 (i.e.155 Mb/s), 46 towns with a capacity of 2.5 GB/s and 9 towns with a capacity of 10 GB/s.In addition, National Data Center, Regional Data Center, WoredaNet, School Net, Ethernet, AgriNet are among major e-government projects that are upgraded following the construction of the National backbone [25].

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

Table 2.5: Status on ICT Infrastructure in Ethiopia as indicated in [25]

b. Applications

Applications are done mainly to automate the back office activities (most are web based). Prioritized electronic services for Ministries and Agencies based on the studied in the e.Government Strategy. A total of 210 E-services are identified in the 2011-2015. 6-7 Common Applications to be hosted at the National WoredaNet as e-Government Implementation Strategy [25].

2.13 ICT initiatives in Oromia Regional States

a. ICT human resource development

Oromia Regional State has a structure which capacitates human resource for the Regional ICT service delivery. There is one core process which is responsible for this task. Through its establishment to now there are many professionals trained on many areas. About 2410 (M=2307, F= 103)IT professionals & Woreda Net operators was trained on Networking Security, Programming Language skills, IT equipment Maintenance. About 325 (M=280 F=45) Woreda Net operators selected from all woreda were trained on school net device maintenance. 43,428 (M=37,123, F= 6,305) civil servant were trained on Basic Computer Applications. [Source: - Oromia ICT Agency Strategic Report].

b. Network Expansion

Regional, zonal and woreda level offices are connected to woredanet infrastructure to share File & Data over the network. Using these facilities Citizen has access to choose best technology that increases their productivities and sharing ideas through e-mail was increasing in urban areas. Forty three Regional Sector Bureaus were connected with WoredaNet facilities. About 197 Rural Districts were connected and 69 newly emerged Districts are on process to connect to the woredanet. All sector bureaus branches at all zone & District level near to the Woredanet facilities was connected and started to share data and Information over the woredanet. Six ICT training centers were connected and sharing educational & other resources from Regional Data warehouse. Six Community Information Centers were connected to provide free information (Internet and other services) for the communities. [Source: - Oromia ICT Agency Strategic Report].

c. Application Development

To establish information access very fast, to disseminate the information to the customer on appropriate time, efficiently & effectively, and to minimize cost and time of collecting news from different sites (rural remote, urban…) Oromia Regional State develops Management information for the Regional State bureaus. Oromia ICT has developed 6 Bureaus MIS by Methodic PLC. There is also MIS applications developed for 14 sector bureaus which is developed by Information security agency. Two ready-made applications were customized for Regional needs. Two applications software were developed in house by IT experts. [Source: - Oromia ICT Agency Strategic Report].

d. Portal and Mail Services

The Regional bureaus and respective offices are using portal and mail service to exchange information, data, letters and documents. [Source: - Oromia ICT Agency Strategic Report].

e. Video conference

Much Regional meeting, conference, training is now given by video conferences with three redundant data centers. As an example 40,000 Regional, zonal, District and municipality top- and mid-level managers trained on good governance package through video conferences.[source:- Oromia ICT Agency Strategic Report].

As indicated in section 1.2.2 and 1.2.3, there are about 630 Woredas/districts connected via woredanet ICT network in Ethiopia. The National Data Center also connected to Regional Data Center through woredanet. According to the e-government implementation strategy of Ethiopian government, each Regional government has its own Regional Data Center. The Regional Data Centers can upgrade and optimize their data centers for the intranet services. For example, they can add Data Center hardware resources such as servers, routers, core switches etc on their own cost. They can also develop their own intranet applications such as mail service, portal, Management Information system (MIS) and can use modern Data Center technologies to optimize the usage of data center resources. [source:- interviews and questionnaires]

In general, based on the facts in section 2.2.11, 2.2.12 and 2.2.13 Ethiopian ICT policy and e-government implementation strategy is a good indicator to adopt XaaS cloud architecture within Regional State. Among the good opportunities within the woredanet ICT infrastructure in Oromia is that recently out of 197 woredas, 161 woredas (82%) are migrated from VSAT technology to ADSL to optimize their bandwidth to access Oromia Data Center resources. And also there are applications developed within the Regional State for effective service delivery.

Therefore, adopting the XaaS cloud architectural technology is probably one of the most feasible technologies to be implemented in Oromia Regional Data center. If further scaled up to nationwide, it will tremendously improve the wastage of scarce resources particularly reducing unnecessary cost of software, human resource and redundant storage in the National Data Center leading to overall improvement of country's economy and government service delivery to the public.

2.14 Factors to be considered for Adopting XaaS Cloud Architecture

In this study, a thorough literature review of factors and opportunities to be considered for adopting Cloud XaaS architecture was conducted .Analyzing these factors and measuring their significance help to choose which cloud XaaS architecture to adopt within government Woredanet [26].

a. Reliability

An outage is the absence of the Cloud service. Kim et al. (2009) stated that an outage is unavoidable and users should take it into account before adopting Cloud Solutions. It might happen for a short or a long time, a few or many times. Even large companies such as Google and Amazon experienced many similar cases in the past and they will have many more in the future. In short, 100 % availability of the service is impossible [26].

b. Security

Users of Cloud Computing give the cloud provider full control over their data and they should trust that this third party will take care of their business, secure the data, and do backups for them. This issue can be partly solved by Service-Level Agreements (SLA) where the conditions of security issues in the contract will be clarified

c. Performance

The main source of performance problems come from the connection quality between the user and the Cloud Computing server, mainly when more users are connecting at the same time and large amounts of data are transferred between the end user and the cloud server. This results in a slowdown in the cloud service.

d. Scalability

Scalability is an important factor that should be taken into account in terms of performance. As the requirements of the Cloud Computing adopters increase, the cloud provider should be able to scale up their resources and infrastructure to satisfy the adopter's new requirements of storage, processing, and connection bandwidth.

e. Compliance and Physical Location

Since Cloud Computing is a fairly young technology, no rules and governmental regulations really exist to set the boundaries and laws regarding the storage of data by enterprises on third-party computing facilities that are shared with others. Moreover, some old regulations already exist concerning the enterprise data privacy, access, and location without taking Cloud Computing into account, and these regulations might be violated by Cloud Solutions.

f. Integration with other Services

Companies need to adopt different types of applications from different cloud providers and these applications might need to interact with each other. At the same time, some companies might adopt a hybrid strategy of Cloud Solutions as public clouds have different characteristics from that of private clouds.

g. Environmental Issues

Environmental issues constitute a real concern for companies in this era as more regulations are issued to minimize the carbon footprint organizations leave behind. A previous 'Forrester' survey concluded that most workers in IT departments believe that the efficient use of energy and recycling IT resources are important issues that should be

handled properly and these factors constitute the main element of green IT. By migrating the IT functionality into the cloud, companies not only reduce their IT infrastructure but also use the energy in an intelligent way. However, other researchers suggest that cloud servers are consuming a huge amount of energy and not all cloud providers are following the best standards in energy efficient consumption, consequently, moving to the cloud does not reduce the global CO2 emissions necessarily.

h. Cost

Cost is a very important factor and opportunity in Cloud Computing. Cost advantages are the strongest driver affecting IT executives' perceptions of SaaS opportunities stated that companies need to spend a big part of their balance on the IT infrastructure, while less than 10 % of their servers can be really utilized, resulting in a big waste of money. In addition, these servers need to be replaced almost every three years and need to be maintained and administrated, increasing the total cost of IT operations radically Cloud Computing can reduce these costs remarkably. Economies of scale for datacenters cost savings can lead to a five to seven-time reduction in the total cost of computing. [26].

i. Innovation

Cloud Computing is considered as an innovative disruptive technology and it results in new types of applications with richer functionality than their in-house counterpart. The service helps IT departments' employees to innovate new core business applications instead of doing the daily backup and maintenance routine tasks. "Cloud computing can lower IT barriers to innovation [26].

j. IT Department's Stand and Changes

While many people might see Cloud Computing as an innovative technology simplifying IT operations, some IT specialists might see it as a real challenging threat. They believe that it will be a threat to their job security by outsourcing their daily IT tasks to a third party company. Even some companies might see Cloud Computing as a big change in handling IT operations, which is somewhat different from the method they used to follow for a long time in handling these operations [26].

k. Bandwidth

Bandwidth is the amount of data that can be transferred over a network, either between servers and storage, or inbound and outbound to the Internet. The XaaS cloud architecture that is going to be adopted should consider the existing woredanet bandwidth capacity. The good opportunity to adopt XaaS cloud architecture for e-government services in Ethiopia is currently the woredaNet ICT infrastructure is migrating from VSAT to ADSL technology. SAT (Very Small Aperture Terminal) is a satellite based WAN technology which is very expensive to expand the infrastructure as well to maximize the bandwidth. The ADSL (Asynchronous Digital Subscriber Line) is a terrestrial WAN technology which is cheaper than VSAT to expand the infrastructure and to maximize the bandwidth. As a result the NDC is maximized its bandwidth from 120Mbps to 420Mbs and Oromia RDC is also maximized its

bandwidth from 10Mbps to 100Mbps.Therefore, these bandwidth can give efficiently the XaaS cloud services on demand especially Storage, CPU and Memory for those clients in the shared pool of the Data Center

ICT Services	Bandwidth Requirement	Available Bandwidth
• Video Conference	**250Mbps**	**40Gbps**
• Portal	**10Mbps**	
• MIS Applications	**15Mbps**	
• Mail Service	**5Mbps**	
• Internet	**100Mbps**	

Table 2.6.NDC Bandwidth Capacity (Source: Interview & Observation)

ICT Services	Bandwidth Requirement	Available Bandwidth
• Video Conference	**100Mbps**	**100Mbps**
• Portal	**1Mbps**	
• MIS Applications	**100Mbps**	
• Mail Service	**2Mbps**	
• Internet	**100Mbps**	

Table 2.7 Oromia RDC Bandwidth Capacity (Source: Interview & Observation)

We ranked these factors to indicate their level of significance based on our literature review. Based on the degree of importance to adopt cloud XaaS architecture, each factor is given **low**- for low significant factor, **medium**-for medium significant factor and **high**-for high significant factor. These factors are going to be used for comparing and analyzing the different venders' XaaS cloud architectures. A cloud XaaS architecture that considers factors that are highly significant will be chosen and adopted in Oromia Regional government Woredanet. This will be done in Chapter 4 of this research.

2.15 Related Works

A number of cloud service architectures have been proposed and implemented with the intent of providing e-government services in a cloud among different venders. These cloud service architectures targeted in providing solutions for major problems that hinder efficient and on –demand government service delivery.

In this section, different cloud XaaS architectures designed by different cloud service providers, how different countries adopt cloud XaaS for e-government services and other businesses are reviewed. Drivers for adopting cloud XaaS architecture, benefits of cloud XaaS architecture and e-government services that can be moved to cloud proposed by different cloud service providers are covered in this section.

2.15.1 Cloud XaaS Architecture for e-Government Services

Government organizations need to consider several cloud deployment models discussed in section when evaluating cloud-computing architecture for e-government services. Some cloud service providers chooses a private cloud model because it is specifically built to provide services internally to an organization. In this section, different venders' portfolio of solutions, products, and services, which enable private cloud architectures for e-government services, are discussed.

2.15.2 XaaS cloud Architecture solutions

XaaS architecture is the combinations of IaaS, SaaS and PaaS. So in order to analyze different companies XaaS cloud computing architecture We try to show the architectures of each company separately with its components.

2.15.2.1 IBM Cloud Architectures

IBM's cloud reference architecture addresses the three major roles in any cloud computing environment: cloud service provider, cloud service creator and cloud service consumer. With this strict separation of concerns, the cloud architecture enables specific perspectives to be assumed in orderto understand the requirements, expectations and value propositions placed upon the system, and the supporting capabilities necessary to fulfill these requirements [32].

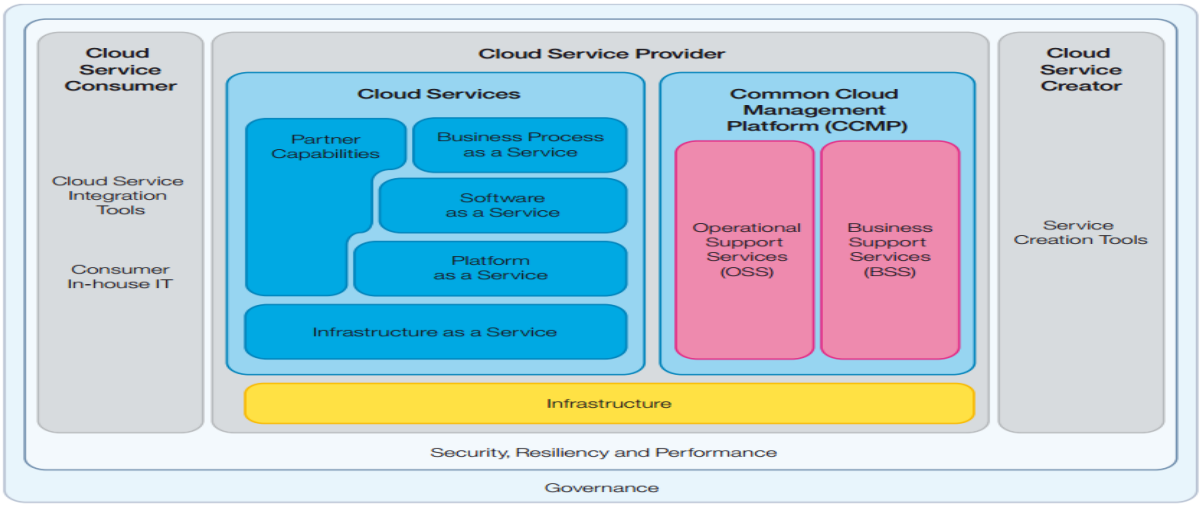


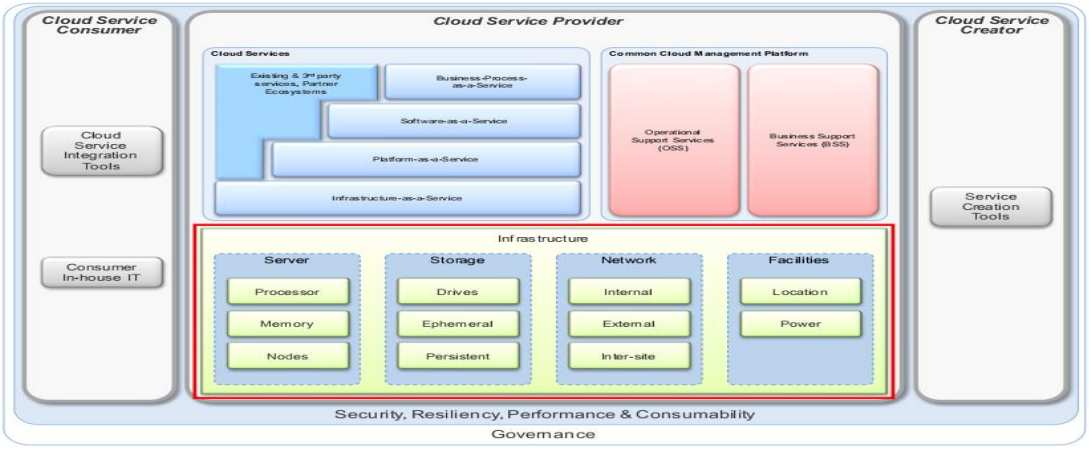
Figure 2.10 IBM Cloud Architectures [32].

Components of IBM Cloud Architectures [32].

- ***Cloud Service Consumer: -*** a simplified interface is needed with well-understood service offerings, pricing and contracts. The value proposition for the service consumer is to get fast, on-demand access to the service they need while only paying for the period of time the service is used.
- ***Cloud Service Provider***: -a highly efficient service delivery and service support infrastructure and organization are needed in order to provide differentiated, well-understood, standardized and high-quality services to end users. Service management makes it possible for significant economies of scale to be achieved. A self-service portal allows exposing a well-defined set of services in a highly automated fashion at a very attractive cost point.
- ***Cloud Service Creator***: -a tooling environment is needed for modeling and assembling service elements (virtual images, for example) as well as an effective means of managing the service lifecycle.
- ***Security, resilience and performance: -***IBM's reference architecture specifications incorporate proven security and reliability technologies as well as simplified security management and enforcement. Built on IBM's published security framework as well as extensive industry security leadership, IBM security surrounding clouds focuses on developing trusted virtual domains, authentication, isolation management, policy and integrity management, and access control resulting in cloud environments that are secure by design.
- **Common cloud management platform: -** optimizing service delivery through visibility, control and automation Well-designed cloud architectures and solutions must address the difficult realities of "layers of complexity" in distributed IT environments. While much industry discussion has focused on infrastructure (network, compute, storage), significant challenges also exist in achieving the low-touch automation required o successfully scale to economically successful cloud solutions. Masking complexity for users, supporting cloud business models and managing heterogeneous, distributed environments are the top service management challenges for any cloud

architecture. It integrates the operational and business management of all layers of the cloud environment, including the CCMP itself.

- **Cloud service delivery models:-**
  - ***Infrastructure cloud services ("infrastructure as a service" or IaaS***):- The capability provided to the



consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications.

Figure 2.11 IBM IaaS [32].

  - ***Platform cloud services ("platform as a service" or PaaS):-*** The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider.

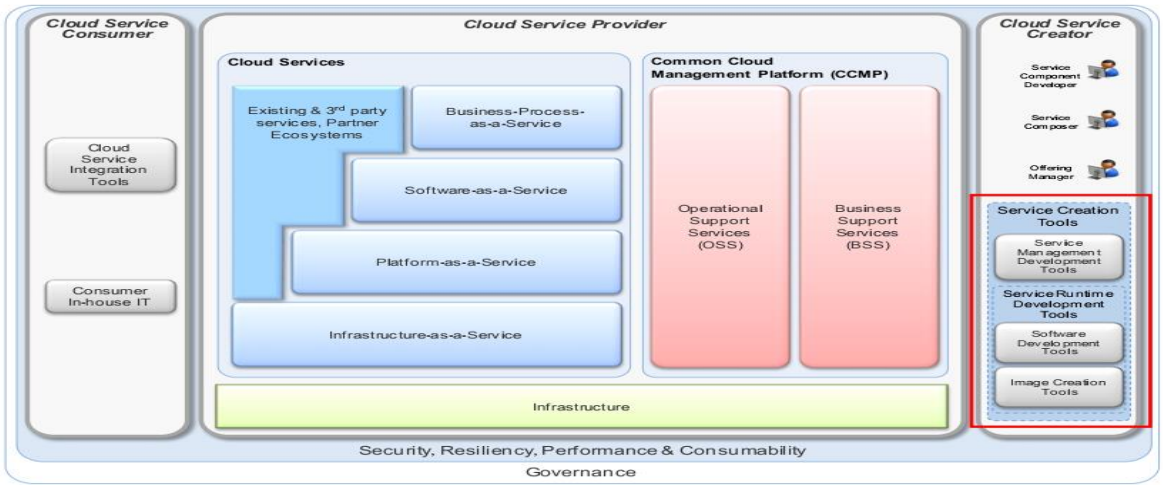


Figure 2.12 IBM PaaS [32].

- ***Application cloud services ("software as a service" or SaaS):-*** The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser(e.g., web-based email).

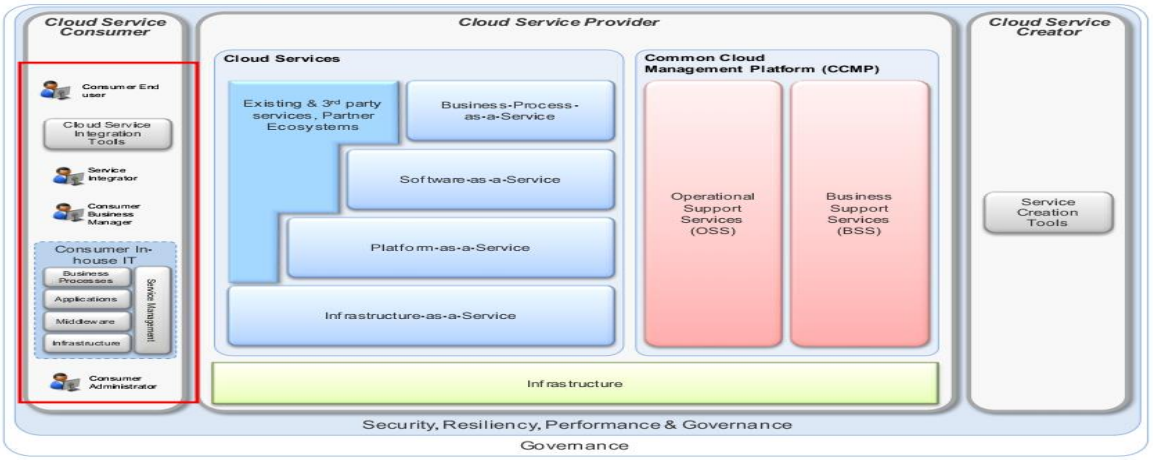


Figure 2.13 IBM SaaS [32].

- ***Business process cloud services ("business process as a service" or BPaaS):-*** Business process services are any business process (horizontal or vertical) delivered through the cloud service model (multitenant, self-service provisioning, elastic scaling and usage metering or pricing) via the Internet with access via web-centric interfaces and exploiting web-oriented cloud architecture.

- ***Service creation tools: -*** Service creation tools are used to create new cloud services. These include tools for developing runtime components, such as virtual machine images or SaaS applications, as well as tools supporting the development of cloud service-specific management configurations and artifacts for all OSS and BSS components.
- ***Service integration tools***: - It is important for customers to be able to integrate cloud services with in-house IT. This functionality is specifically relevant in the context of hybrid clouds, where seamless integrated management and usage of different cloud services and in-house IT is critical.

2.15.2.2 HP Cloud Architecture

As a part of the HP Converged Cloud portfolio, HP Cloud System is built on a common architecture that delivers the industry is most complete, integrated, and open cloud platform. HP Cloud System enables enterprises and service providers to build and manage services across private, public, and hybrid cloud environments with ease, reducing complexity and fostering business growth. An HP Cloud System offering provides a range of services and has three integrated offerings [31].

- **HP Cloud System Matrix:** Enables us to deliver infrastructure as a service (IaaS) and provisions infrastructure and basic applications in minutes.
- **HP Cloud System Enterprise**: used to deploy private and hybrid cloud environments and the full range of service models (IaaS, platform as a service (PaaS), and software as a service (SaaS). This offering provides a single service view from private cloud to public clouds to traditional IT, with advanced application-to-infrastructure lifecycle management.

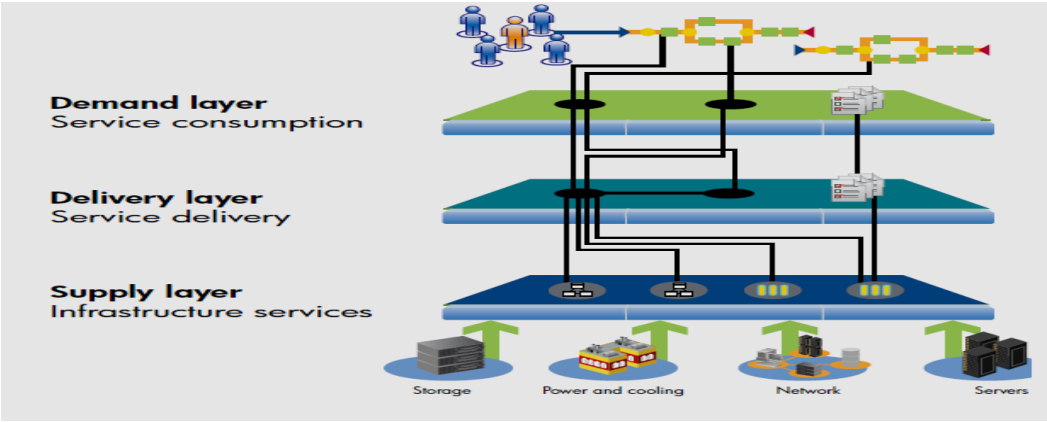


Figure 2.14. HP Conceptual Cloud IaaS Architecture in [31]

HP Cloud System provides these capabilities using the three-layer architecture shown in Figure 2.7, which enables IT as a service. Within this architecture:

- **The supply layer**: provides all the infrastructure services for Cloud System; this is where the physical and virtual assets reside.
- **The delivery layer:** provides application service delivery.
- **The demand layer:** contains the self-service portals and is where services are actually consumed by end users or subscribers. Cloud System is optimized for HP infrastructure: blade servers, storage, and networking and technology from HP are the ideal environment for Cloud System. Blades provide a common modular infrastructure designed for efficiency, scalability, and flexibility. From a management perspective, Cloud System provides a complete management environment to help ensure the cloud service meets the needs of the end user.

a. Overview of HP Cloud System Matrix

HP Cloud System Matrix is an entry cloud solution for customers who want to set up their own private cloud. This offering enables quick deployment of a private IaaS solution featuring a self-service infrastructure portal for auto-provisioning, along with built-in lifecycle management to optimize infrastructure, manage the resource pool, monitor applications, and help ensure uptime.

The HP Cloud System Matrix offering is a complete private cloud solution and includes all the features expected in the cloud:

- An infrastructure-centric self-service portal;
- A pool of shared resources;
- Automated provisioning, flexing, and release;
- Metering for usage;
- Ubiquitous access.

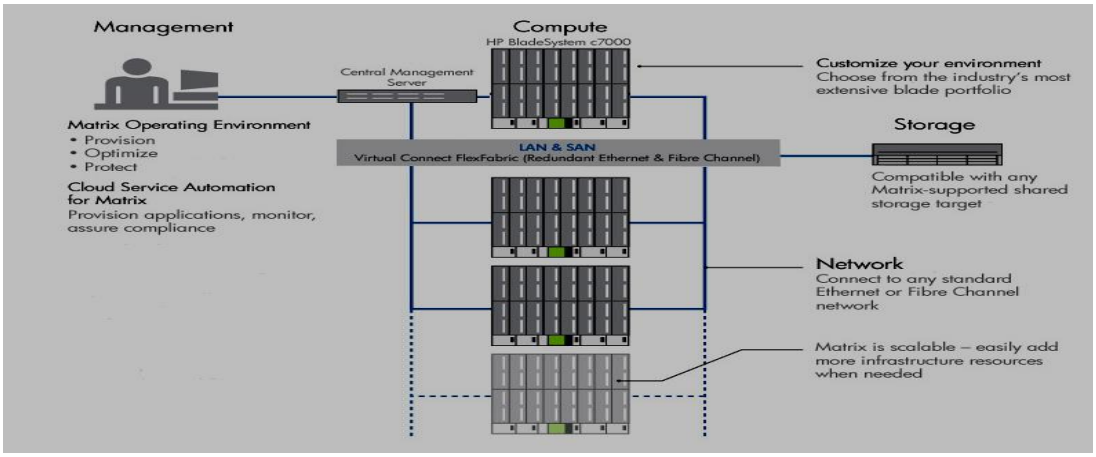


Figure 2.15: HP Cloud IaaS Architecture [31]

Cloud System Matrix is an integrated hardware, software, and services solution that helps us realize the full value of cloud computing as quickly as possible.

b. Description of the Components

The core elements of a Cloud System Matrix solution are:

- **HP BladeSystem c7000:-** Incorporates modular and flexible compute, embedded management, network, and storage resources to provide a common, modular infrastructure that is cloud-ready and can accommodate continually changing business needs.
- **HP Virtual Connect: -** Virtual Connect is an essential foundation element in Cloud System. Inherent in Cloud System functionality and the powerful automation capabilities of its operations is the ability to move workloads from one server to another without human intervention or coordination.
- **HP Matrix Operating Environment: -** The Matrix Operating Environment includes an integrated service designer, self-service infrastructure portal, and auto-provisioning capabilities. It includes the tools to manage and optimize resource pools, multi-tenancy, and a recovery management solution.
- **HP Cloud Service Automation (CSA) for Matrix: -** HP Cloud Service Automation (CSA) for Matrix incorporates a starter edition of HP Server Automation software and HP Site-Scope software.
- **Supported operating systems: -** Windows, Linux and HP-UX.

- **Supported hypervisors include: -** VMware, Microsoft Hyper-V and Integrity VMs.

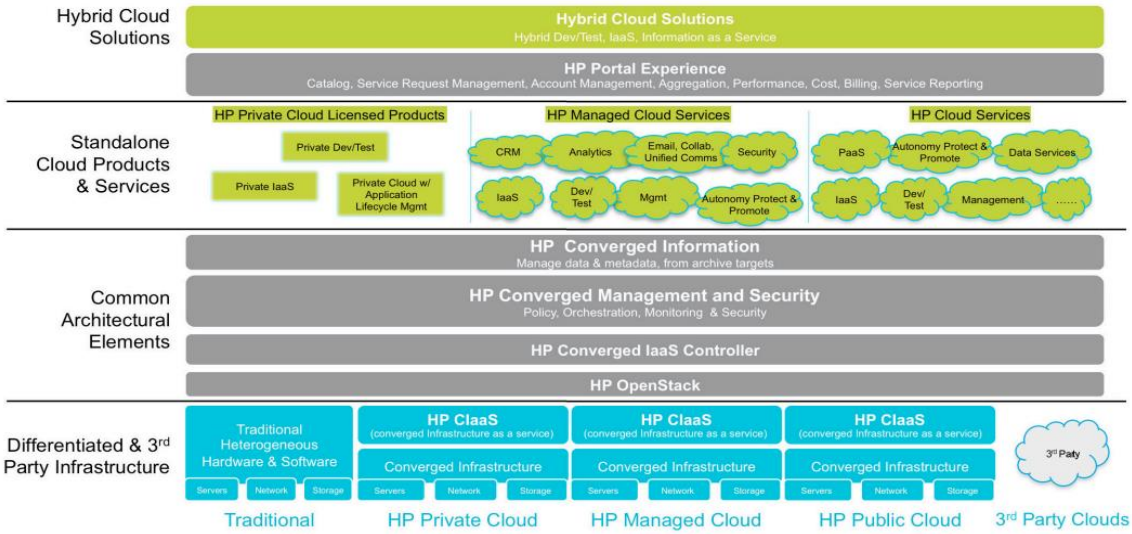


Figure 2.16 HP Converged Cloud Architectures **[31]**

2.15.2.3 Oracle Cloud Architectures

2.15.2.3.1 The conceptual view of the architecture

As shown in the diagram below, It brings together three key Cloud perspectives, the provider, consumer, and the broker [33].

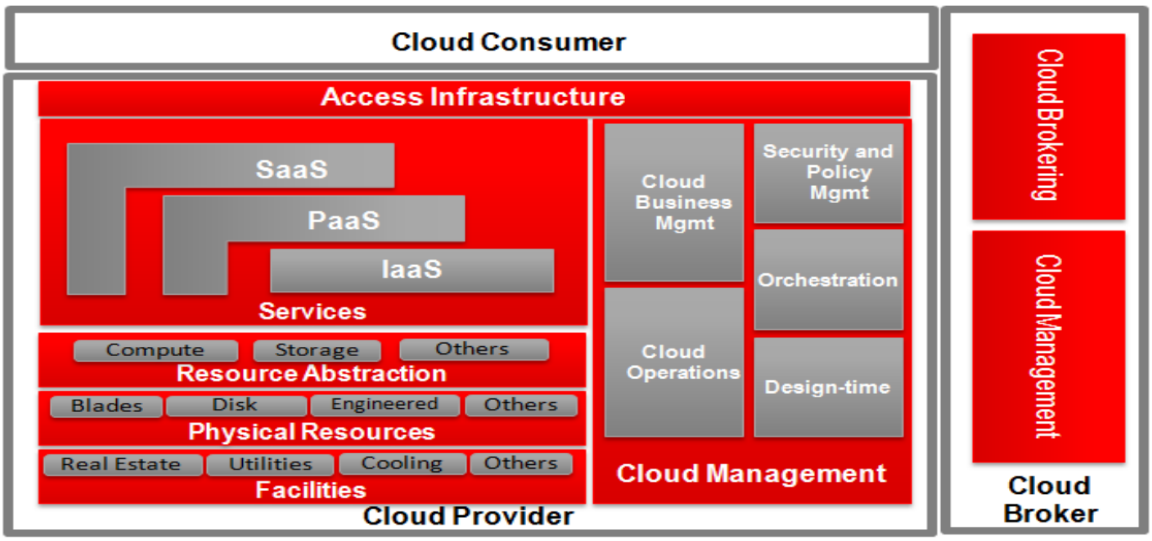


Figure 2.17 Conceptual Views of Cloud Architectures [33].

a. Descriptions of each components

- ***Cloud provider: -*** is the most important and most complex of all. Infrastructure for the Cloud is usually of unprecedented scale and stringent requirements. Implementing the Cloud and maintaining it to satisfy the SLAs of the consumers requires extensive planning and precise execution. A Cloud provider can spread the costs of facilities, across consumers to achieve economies of scale [33].
- ***Facilities expense: -*** may include the cost of real estate, cooling, utilities, and rack space among other things.
- ***The physical infrastructure: - M***ay include blades, networks, engineered systems, and storage disks. These resources must be pooled and provisioned through grid technologies in order to support the elasticity and scalability demands of Cloud infrastructure. The physical resources need to be logically partitioned and secured in order to support multi-tenancy [33].
- ***Resource abstraction layer:-*** provides the capabilities to logically abstract the physical resources.
- ***Service infrastructure: -*** exposes the Cloud services to the consumers through the access infrastructure. Many resources can be offered as services but the ORA conceptual model defines three broad categories of services listed below:
    - Infrastructure as a Service (IaaS)
    - Platform as a Service (PaaS)
    - Software as a Service (SaaS)

2.15.2.3.2 The Logical Views of the architectures

This section describes the logical view of the Cloud infrastructure. Figure 2.18 shows the logical layers and

Key logical components of the Cloud infrastructure. The access layer decomposes into two important sets of functionality: interfaces and network components. The Cloud needs a variety of interfaces to allow for access to the underlying services as well as its management capabilities. In addition to the end-user facing interfaces present in the access tier, there will be several operator specific capabilities present [33].

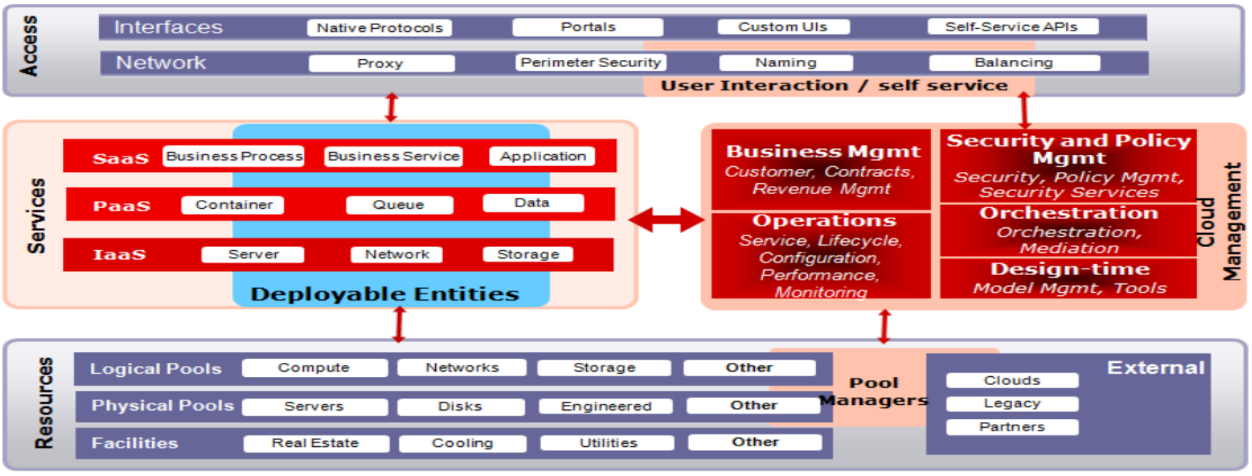


Figure 2.18 Logical Views of the architectures [33].

a. Descriptions of each component [33].

- ***Common Cloud management layer:-*** provides the management capabilities required for all types of Services. A unified management framework provides a holistic view of the infrastructure and end-to end visibility. The management layer provides support for both build-time and run-time activities.
- ***Logical and physical pools: -*** Contains resources that virtualized or physical resources managed by the pool manager. These resources may be fairly simple in nature (as the single virtualized server example above) or complex (such as a highly-available or clustered Java application platform).
- ***External resources: -*** may include third party Cloud services, legacy systems, and partner services.
- ***The services layer***: - shows the concept of deployable entities that are self-contained, logically grouped, and packaged service resources that can be used to rapidly provision the services. The deployment entities are "templatized" to automate and accelerate the provisioning of services.
- ***Access Interface: -***A key characteristic of the Cloud architecture is automation and the ability to self-service most of the consumer needs. To that effect, access interfaces of various forms should be provided to the consumer to access the self management capabilities of the Cloud. The type of interfaces may range from sophisticated self-service portals to low level APIs to automate the management of the Cloud resources.
- ***Cloud Operations:-***this is operational capabilities of Cloud Management.
- ***Security and policy management***:- provides services common to both the build-time and runtime

  Functions of the Cloud management layer.
- ***Model management: -*** provides capabilities for developers and deplorers to create deployable entities. It supports this build-time functionality by exposing Cloud resources, validating, and deploying the deployable entities.

2.15.2.3.3 Requirements and Reference Architecture for PaaS Private Cloud

The figure below shows the basic architecture of a platform-as-a-service cloud offering that a central IT function would set up within an enterprise.

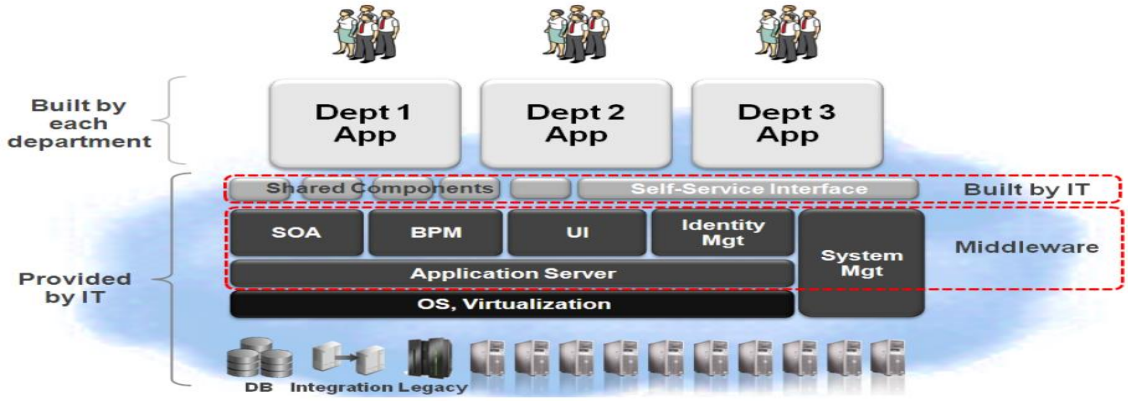


Figure 2.19 Basic platform-as-a-service cloud architecture.

The physical infrastructure includes servers, legacy systems such as mainframes, integrations, and database resources. The lowest layer of software above this is at the operating system level and may or may not include virtualization technologies such as the Oracle Virtual Machine hypervisor. Above this resides middleware such as Oracle Fusion Middleware, including application servers and technologies such as service-oriented architecture (SOA), business process management (BPM), user interface (UI) technologies, and identity management. Systems management such as Oracle Enterprise Manager spans the entire stack. Upon this foundation are the custom elements built by the central IT function, including shared components such as SOA services and BPM processes as well as the self-service interface that the enterprise's internal cloud customers interact with.

2.15.2.3.4 The Basic PaaS Private Cloud Life-Cycle

Getting underway with a PaaS private cloud involves four macro-level steps. First, the central IT function builds the platform, starting with out-of-the-box middleware and creating the enterprise-specific shared components and self-service interface.

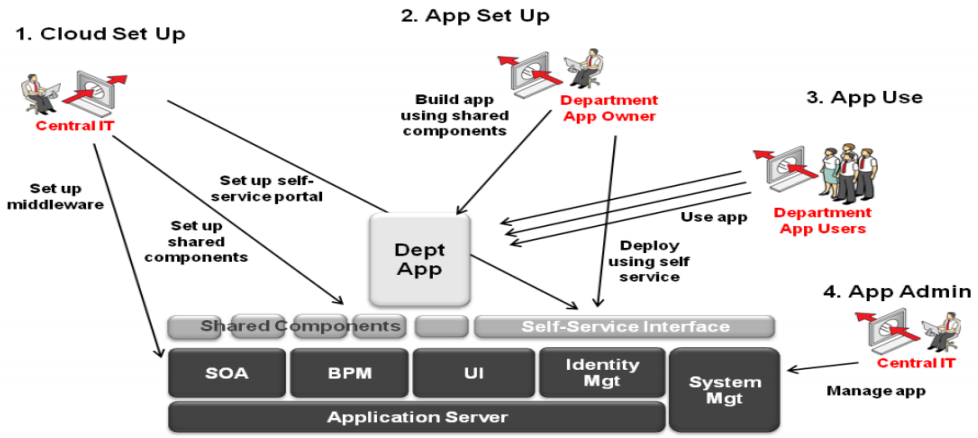


Figure 2.20 .Basic PaaS private cloud life-cycle.

Once the basic platform is up and running, the application owners within the enterprise's departments can set up their respective applications. Again, depending on the nature of the domain and enterprise, this may involve fairly simple application composition using platform components, or it may involve a substantial amount of custom application development. Once an application has been deployed on the platform, the third step is simply the use of the application. From the users' perspective, the application is no different from any other network/Web-based application they would use within the enterprise—there is nothing special about the fact that it's running on a cloud platform as far as they are concerned.

2.15.2.4 Cisco Cloud Architectures

Cisco has developed the depiction, shown in Figure 2.11 of a cloud reference architecture model, which portrays the architectural layers, connected via APIs and repositories. If we study the framework more closely, the following aspects can be articulated [34].

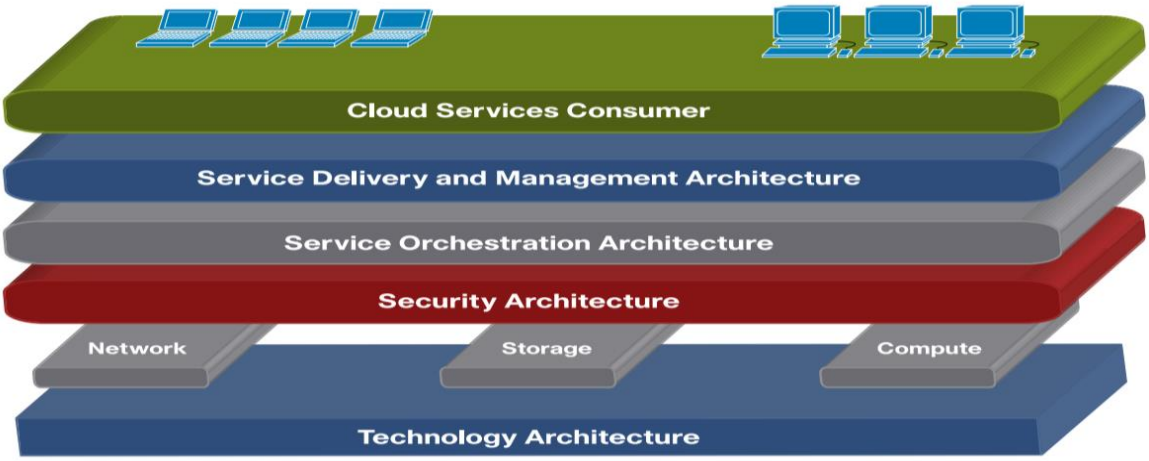


Figure 2.21 Cisco Cloud Architectures [34].

Descriptions of Each Component

- ***Data Center Technology:*** **-**At the foundation of this framework is the data center technology architecture, which Consists of three salient blocks of network, compute, and storage. This layer hosts all the services that are delivered to a cloud consumer or subscriber.
- ***Security Layer***: - It is the important layer of the architectures. The key takeaway in this layer is that security is blanketed as an end-to-end architecture across all aspects of the framework. Security is considered as one of the key challenges to be solved in a cloud framework; hence, it has to be accounted for in a comprehensive sense [34].
- ***Service Orchestration layer:*** **-**which is implemented with configuration repository enablers. The configuration repository stores key information such as service catalogue, asset inventory, and resource-to-service mappings.
- ***Consumer-facing layer***: -usually exposed via a portal-like solution. This is the layer where service is defined, requested, and managed by the consumer.

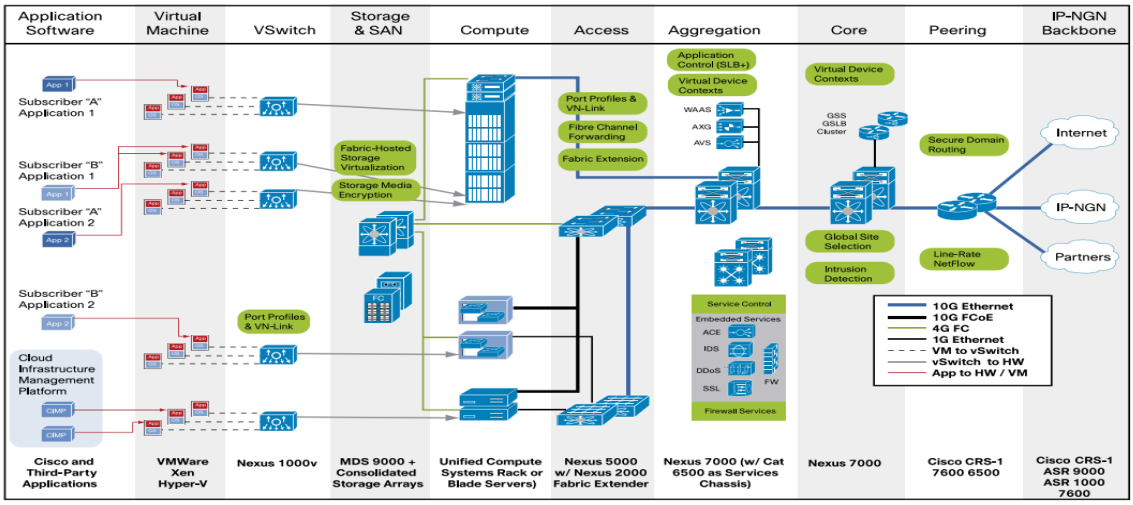


Figure 2.22 Cisco Cloud Data Center Technology Architecture [34].

The technology architecture in Figure 2.13 represents a next-generation cloud data center. It is based on Cisco's and the ecosystems partners' data center building blocks. The above technology architecture represents only a sample of building blocks of a cloud data center. Moreover, the end-State technical architecture would not only contain the components listed above and below but would also be governed by different types of service and regulation/compliance requirements.

2.15.2.5 NIST Cloud Architectures

2.15.2.5.1 Conceptual Reference Model

Figure 2.12 represents an overview of the NIST cloud computing reference architecture, which identifies the major actors, their activities and functions in cloud computing. The diagram depicts a generic high-level architecture and is intended to facilitate the understanding of the requirements, uses, characteristics and standards of cloud computing [35].

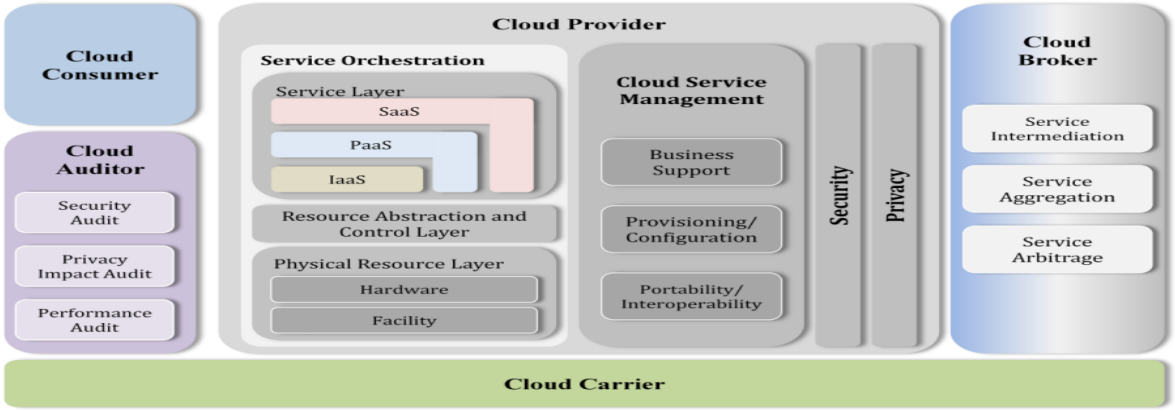


Figure 2.23 Conceptual Reference Model of NIST Cloud [35].

As shown in Figure 2.12, the NIST cloud computing reference architecture defines five major actors: *cloud consumer, cloud provider, cloud carrier, cloud auditor* and *cloud broker*. Each actor is an entity (a person or an organization) that participates in a transaction or process and/or performs tasks in cloud computing.

Descriptions of Each Component

Cloud consumer: - The cloud consumer is the principal stakeholder for the cloud computing service. A cloud consumer represents a person or organization that maintains a business relationship with, and uses the service from a cloud provider. A cloud consumer browses the service catalog from a cloud provider, requests the appropriate service, sets up service contracts with the cloud provider, and uses the service. [35].

- ***Cloud Provider: -***A cloud provider is a person, an organization; it is the entity responsible for making a service available to interested parties. A Cloud Provider acquires and manages the computing infrastructure required for providing the services, runs the cloud software that provides the services, and makes arrangement to deliver the cloud services to the Cloud Consumers through network access. [35].
- ***Cloud Auditor: -*** A party that can conduct independent assessment of cloud services, information system operations, performance and security of the cloud implementation [35].

- ***Cloud Broker: -*** An entity that manages the use, performance and delivery of cloud services, and negotiates relationships between Cloud Providers and Cloud Consumers [35].
- ***Cloud Carrier: -*** An intermediary that provides connectivity and transport of cloud services from Cloud Providers to Cloud Consumers [35].

2.15.2.6 Intel Cloud Architectures

2.15.2.6.1 Conceptual Reference Model

Over time, Intel has experimented with or deployed a variety of SaaS applications, including four of the five most widely used SaaS categories: customer relationship management (CRM), human resources management systems, collaboration, and business expenses.

They surveyed 14 SaaS solutions that had been used at Intel. Of these, 11 were in production use: these included expense and time-card tools, online learning, hiring tools, and health benefits. Table 1 summarizes the characteristics of these applications.

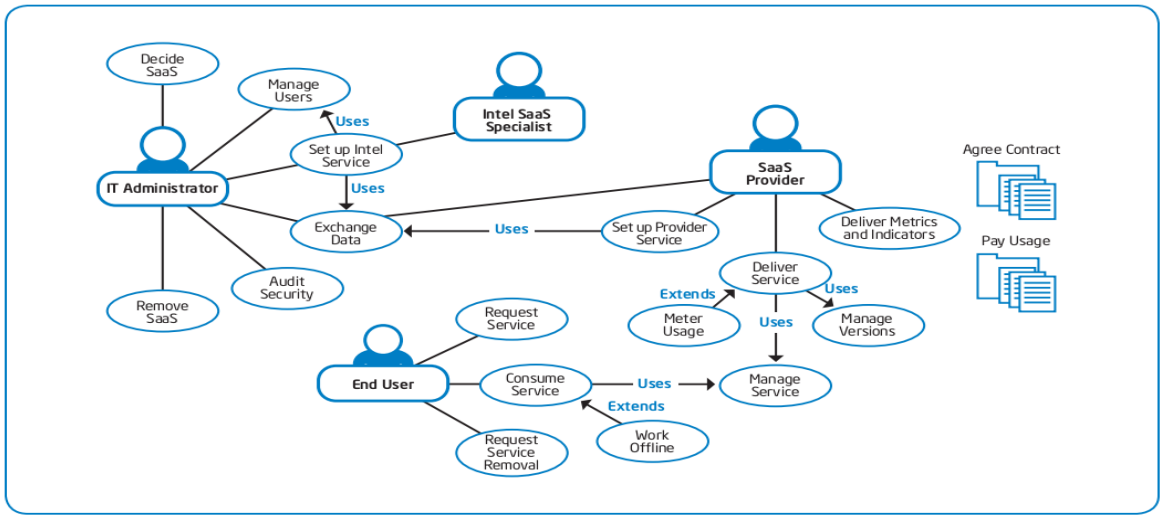


Figure 2.24 Software as a service (SaaS) architecture use-case

a. **End users-** Primary end users are individual workers at Intel who use SaaS applications for job-related activities. Workers are located within the enterprise or connected to Intel while traveling or working from home.

b. **SaaS provider**- This is the external provider that delivers a software service over the Internet to Intel. The model describes a typical SaaS solution in which back-end integration is required. It encompasses the entire service life cycle and includes use cases to define SaaS selection, initial setup at Intel and the SaaS provider, user consumption of the service, ongoing data exchange and administration, and service end of life

c. **Multi-tenant efficient-**The design should support multiple tenants using a single instance of the application. The data must be segregated for each tenant.

d. **Configurable**- The application can be configured to meet the needs of each tenant, using metadata and a metadata execution engine—also known as a business rules engine. Routine configuration changes should be possible without the need to coordinate downtime with other tenants.

e. **Scalable**- Multi-tenant usage can result in millions of users. Applications should be designed from the ground up to scale up and scale out—and to be able to do this dynamically, on demand

The conceptual architecture is intended to represent a three- to five-year vision of SaaS architecture, free of implementation technology details, and to establish common capability definitions. The conceptual architecture depicts all the key capabilities required in a complete SaaS offering, the logical separation of capabilities into tiers, and the logical grouping of capabilities. We do not expect that individual SaaS applications will necessarily include every capability described in the conceptual architecture

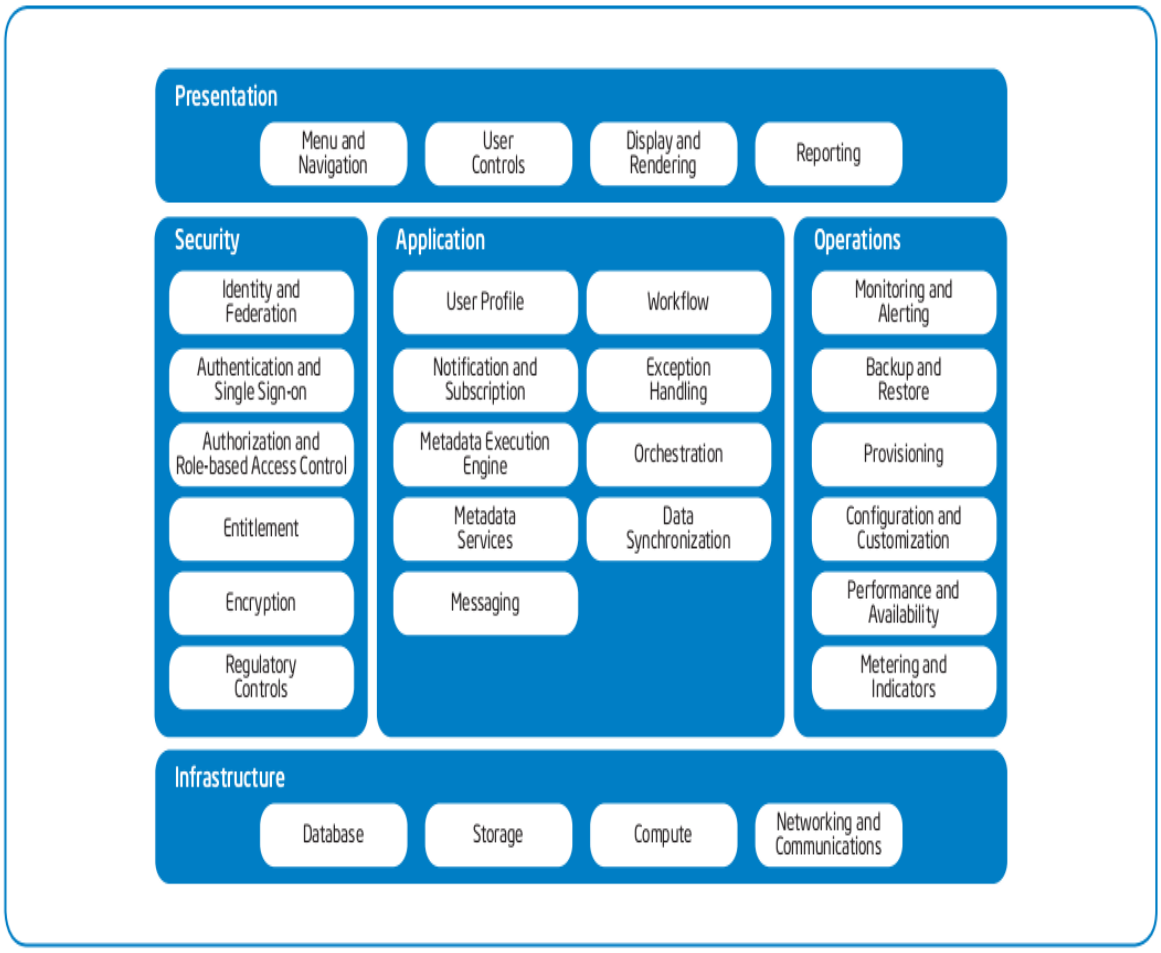


Figure 2.25. Intel IT's conceptual architecture for software as a service (SaaS)

It includes capabilities in five categories:-

- **User profile-**The attributes and information that describe a user, such as name, e-mail address, and role.
- **Metadata execution engine.** Statements that define or constrain some aspect of the business. They are intended to assert business structure or to control or influence the behavior of the business.
- **Metadata services.** Information about which data is contained and exposed within an application and about how content is organized.
- **Workflow**. The defined series of user-based tasks within a process to produce a final outcome. An example is creating a purchase order.
- **Exception handling.** The process of raising and managing exceptions within an application. This includes how application errors are exposed to the user and how error messages are logged.

- **Orchestration**. The series of technical tasks performed within a process to produce a final outcome. An example is an extract, transform, and load sequence to move data between business applications.

- **Data synchronization.** The capabilities for synchronizing data held within the application with external data

Figure below, on the next page, shows the high-level reference architecture for a typical SaaS offering at Intel. It includes summary views of data interchange, manageability, and security capabilities. We also developed more detailed architecture designs for each of these areas; key aspects of these are summarized in the following sections.

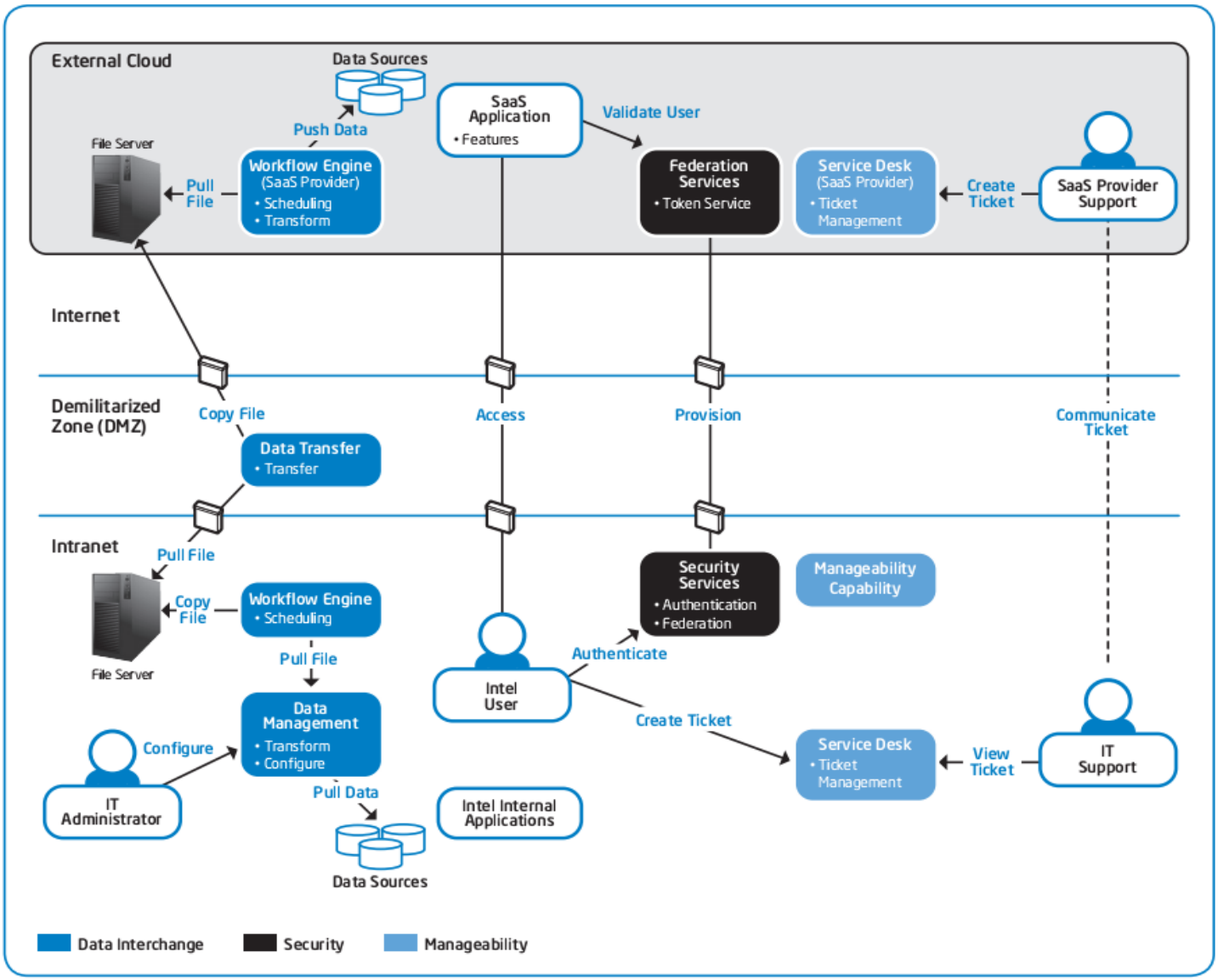


Figure 2.26. Intel IT's summary view of software as a service (SaaS) reference architecture.

2.16 Adoption of Cloud XaaS Architecture in Different Countries

2.16.1 Adoption of Cloud XaaS Architecture in Africa

In Africa, several cloud computing projects are already under way or under study. Of these projects, the most solid are the result of partnerships between international players and African economic operators. The benefits to be derived from this advanced IT service appear to have convinced African players, and the indications are that the characteristics of cloud computing would be very appropriate to the African Context. This would explain the interest shown by the various stakeholders, each of which is seeking to tap into those benefits as speedily as possible and get in at the beginning, in spite of the technical Shortcomings and regulatory difficulties associated with the deployment of cloud computing technology. [36].

- **At the ICT development level:-**The situation in Africa is characterized by relatively favorable network infrastructure development with constantly improving international connectivity. In recent years, several international cables have model and fall on each side of the continent, favoring the growth of telephone and Internet traffic and the emergence of an ever-increasing number of data centers. This development, initially driven by the very rapid expansion of mobile telephony, has been boosted by the high-capacity requirements stemming from the introduction of broadband technology. [36].

Where connectivity to the international telecommunication network is concerned, Africa has seen the arrival of several international cables on each side of the continent and the emergence of an increasing number of shared data processing centers. However, confidence in the prevailing legal systems in African countries remains at an unsatisfactory level in terms of data protection. A consultation focusing on application of the European Directive on personal data processing and the free movement of data has been launched in the interests of addressing the issue of data transfer outside the European Economic Area (EEA) [36].

2.16.2 Adoption of Cloud XaaS Architecture in China

Although the Chinese government first introduced policies specifically aimed at cloud computing technology in 2010, a framework for government support for related technology and industry already existed within China's medium to long-term science and technology planning document. Government support and priorities for cloud computing have guided investment and development of the industry, but this appears to have produced mixed results in terms of level of technological sophistication achieved. [37].

According to criticisms published by MIIT, China's technical capacity for developing cloud computing technology is limited by systemic weaknesses in the software and integrated circuit industries, which include: lack of core technology, insufficient innovation capabilities, and serious structural personnel problems due to a lack of high-level, well-rounded personnel in leadership positions. [37].

The Chinese University of Hong Kong transforms their IT infrastructure with Cisco Data Center Business Advantage Architecture. The university centralized and virtualized its information technology resources by deploying cloud IaaS architecture with Cisco Unified Computing System. The business challenge, Network solution and business results are discussed as follows [38].

a. Business Challenge

The University has more than 15,000 students, 1,400 faculty staff and 5,100 administrative staff including an IT department - the Information Technology Services Centre (ITSC). The entire campus is connected to the University Campus Backbone Network via high-speed Gigabit Ethernet links. Connections within the campus network are via high speed 10 Gigabit or Gigabit Ethernet links. [38].

The university's data center was supporting more than 500 application servers, mostly linked by a Cisco 4 set of Catalyst 6500 switches. Maintenance and management was an ongoing challenge as the data center comprised different hardware and software platforms, resulting in system conflicts and incompatibilities. [38].

b. Network Solution

After discussions with Cisco technical specialists they agreed that the most effective solution to overcome their data center challenges was to centralize and virtualized the university's computer network and computing resources based on Cisco's cloud Data Center Architecture, a virtual network system which also enables a private cloud platform. Virtualization replaces the traditional design of an application running on one physical server. Instead, a single physical server can host multiple virtualized servers supporting multiple applications [38].

c. Business Results

With a virtualized network and data center available to all departments as a service, costs are charged on a monthly basis which is easier to manage within each faculty's or departments annual operating budget. By breaking down IT silos and creating virtual network and computing resources, the ITSC expects to further reduce its energy consumption and cooling costs.

Virtualizing the data center servers also dramatically reduces cabling requirements and requires significantly less rack space to deliver more compute and network capability. The new Nexus switch architecture and FCoE (Fiber Channel over Ethernet) technology allows the Chinese University to reduce up to 50% of Ethernet and Fiber Channel switches, saving up to 80% of cabling and rack space compared to a traditional data center. [38].

2.16.3 Cloud Adoption In India

At present, the Indian market does not have a mature ecosystem that supports cloud IaaS services. As such, the cloud IaaS market in India is yet to take off. A few players from the service provider segment such as Tata Communications, Wipro and Net Magic have announced services that are likely to evolve into more stable cloud

offerings. Tata Communications, for example, offers its customers an advanced virtualized environment with flexible arrangements to enhance capacity. [39].

- **Drivers for cloud IaaS services in the Indian market**

While the market is currently at an embryonic stage, the presence of several positive drivers lends to the promise of cloud IaaS services evolving into a fast-growth segment [39].

- ***SMB segment: -*** The size of the Indian SMB market exceeds that of any other country in the Asia-Pacific Region. India is also forecasted to achieve the highest SMB IT expenditure growth rates, with more than 50% of the expenditure expected to be dedicated to hardware.
- **Low profitability of third-party data center service providers: -** Third-party data centers currently operate at extremely thin margins. This can be largely attributed to the product mix, which leans toward basic co-location services rather than value-added, high-margin services such as managed hosting. [39].
- **ISP telecom operators: -** Moreover, in the Indian context, internet service providers(ISPs) own and operate many of the larger data centers. Telecom ISPs have invested substantially in bandwidth creation, and currently, the market has excess bandwidth capacity. Introducing cloud IaaS services to their current portfolio will help ISPs increase bandwidth usage and increase customers' switching costs.
- **Enterprise data center expenditure**: - With significant power and electricity overheads, enterprise data centers are a major drain on enterprise IT budgets in India. Ernst & Young's survey indicates that more than 80% of the enterprises surveyed are considering initiatives to reduce the overall footprint of their data centers. The average size of an enterprise data center in the Indian market is in the range of 1,000–1,500 sq. ft.
- **Maturing traditional IT market:** - The growth projection for the domestic IT market is between 2008 and 2013 is expected to be 15.8%, as against the average annual growth of 25% recorded during between 2003 and 2008 (IDC estimates). With slower growth and increasing competition in the traditional IT outsourcing services market, vendors are seeking new business models to increase their revenue streams [39].
- ***Public cloud adoption accelerates in India: -***Indian businesses will spend 36% more on public cloud services this year to lower costs and increase business flexibility, according to research. Cloud-based IT, particularly public cloud services, reduces the upfront costs associated with hardware and software purchases and implementation. In addition, public cloud services make capacity planning less critical as a result of on-demand computing. According to Gartner, public cloud services sales will be worth 24.54 billionINR this year, a 36% increase compared to the last year. I40]

2.16.4 Cloud Adoption In Kenya

The adoption drivers among providers and users in Kenya are consistent with what the literature has established, particularly cost savings in hardware, software and personnel, improved system performance and management, flexibility in access to processing and storage capacity as well as higher elasticity degree. Adoption of cloud

computing in Kenya is fairly recent; with most organization shaving adopted either 2010 or 2011. This partly implies the appreciation of the impact of the technology is rather limited. More organizations utilized pure private cloud (39%) [41]Compared to utilizing a public cloud (22%) [41]. the choice is more likely a result of concerns around security and control of access of organizational data. The key barrier to entry into the cloud business was the cost of investment. The cost of cloud services was also found to be a key determinant of adoption and usage. In addition, lack of technical skills had also significantly hampered the adoption and usage of cloud computing. Specific skills lacking are security, architecture and design, storage and virtualization skills. Consistent with literature on cloud adoption in other developing countries, concerns about the reliability of service, security and privacy of data, geographical location of the data are some of concerns of potential and current users or provider's .Majority (80%) [41] were not aware of either policy or legal frameworks for cloud computing. Even those who were aware, majority indicated that these frame works were not as flexible, comprehensive and effective as they would have wished [41].

2.16.5 Cloud Adoption In Ethiopia

2.16.5.1 Cloud Computing Framework for Ethiopian Higher Educations.

Shaik Saidhbi from Arba Minch University have done cloud computing framework for Ethiopian higher educations. The aim of his work was to identify the particularities of using Cloud Computing within Higher Education in Ethiopia. Mainly, he has considered the risks and benefits of cloud architecture and proposed a Cloud Computing framework for EHEIs. And also his study presents a cloud adoption strategy proper for Universities. His research discusses different cloud topics like cloud deployment types, service delivery models and related concepts. It also discusses the benefits and limitations of cloud computing to higher education institutions. His research investigated the potential benefits of using Cloud Computing in teaching-learning environments to overcome the current learning and service delivery system limitations. The research shows that hybrid cloud computing is a better choice for deployment in the universities since it gives the combined benefit of private and public clouds. The proposed hybrid Cloud Computing would be used as a road map for further studies on the topic [42].

2.16.5.2 Cloud Computing Based HPC: A Framework for Ethiopian Universities

Samuel Fentahuen in Adama science and technology university have done research on cloud computing based HPC a frame work for Ethiopian universities. He proposed a framework that consists of a private cloud infrastructure and a HPC infrastructure, He use Open Stack open source cloud operating system for deploying a cloud infrastructure and they also use Hadoop as an HPC cluster. These technologies are in their own right; however, when they are joined together, the benefits a University experiences are substantial. Although the environment can be complex, an enterprise can see substantial synergies by joining an Open Stack private cloud with an Apache Hadoop environment [43].

They also explain about A common deployment model for HPC in a private cloud environment is to deploy Open Stack's Swift storage technology joined to an Apache Hadoop Map Reduce cluster for processing. The advantage of using this architecture is that each University will have a scalable storage/compute node [43].

2.16.5.3 Cloud Computing Conceptual Security Framework for Banking Industry

Meskerem Alemu, Abrehet Omer from HiLCoE School of Computer Science and Technology, Computer Science Department of computer science has done on cloud computing conceptual security frame work for banking industry [44].

They assessed cloud computing architecture, reference model, service, threat and attacks, policy, standards and guidelines. Similarly, their assessment has also been made on bank industry regulatory security and compliance requirements. Based on their assessments they designed Conceptual Cloud Computing Security Frameworks for Banking Industry. Their proposed frame work addresses security, privacy, legal, compliance and regulatory risk though identifying and representing systems that need to be secured in cloud system with Cloud Model, and in order to preserve security and privacy, major security component is identified and represented with Security Model. To facilitate meeting legal and compliance issue Compliance Model is set. More so, in the framework Risk Matrix is set for assessing and determining risk exposure of bank asset applications while moving to cloud deployment option. Moreover, they integrated control domain and compliance model component is also proposed as a base for setting security major. Finally, for each defined control domain, security major/ strategy (tools, products, Guidelines and Practices) is proposed [44].

2.16.6 Summary of Related Works

Literature reviews and related works in section 2 have discussed cloud computing concepts, e-government services that are to be placed in private clouds or public clouds depending on characteristics of the applications. E-government applications with classified data have to be put in private cloud and those without classified data can be put in public cloud. Cloud IaaS architecture designed by different cloud service providers such as Cisco, IBM, Oracle and HP are discussed. Different countries adopted cloud IaaS architecture based on these cloud services providers' architecture are discussed.

Based on e-government services placement considerations discussed in section 2., the private cloud deployment model is a preferable for Ethiopian government data centers. Factors to be considered before adopting cloud IaaS architectures that were discussed in section 2.1.16 will be a base to choose an architecture that is going to be adopted. Based on literature review of section 2.1.16, significant factors to be considered before adopting cloud IaaS architecture will help to decide which architecture can be adopted according to Ethiopian context. Comparison and selection of a cloud IaaS architecture that can be adopted is discussed in the first section of chapter 4.

CHAPTER THREE

3. Cloud Computing Assessments and Findings in Ethiopia

3.1 Overview

The primary data collection was based on questionnaires developed according to problem statements described in section one and distributed to IT managers, National Data Center Experts and Ethio-Telecom broadband internet IT professionals.

The survey questions were derived from multiple sources: areas of interest highlighted in the literature review process as well as current surveys and past surveys aimed at adoption of cloud computing services. The sampling method used is non-random sampling (*Convenience or accessibility sampling which* involves asking a sample of people to respond to a survey. An example is distributing survey questionnaires at a meeting of a local beekeeping association or at a beekeepers' convention) method, particularly judgment sampling method to obtain sample for the research.

As a result, Ethiopian government ICT infrastructure and services status for adopting cloud XaaS (SaaS, IaaS and PaaS) architecture was assessed. Questionnaires are developed to survey ICT service delivery at Oromia ICT Agency, National Data Center and Ethio-Telecom internet and data services .Government sectors/bureaus who have automated their business based on BPR (Business Process Reengineering) were surveyed. The levels of respondents are IT managers, Data Center Administrators, Web Developers, Data Base Administrators, national data center experts and Ethio-Telecom broadband internet IT professionals. We focused on government bureaus which are connected to Ethiopian government VPN (Virtual Private Network) called. The study specifically focused on those sectors that have automated their business and have MIS application deployed in Data Centers.

The questionnaires were distributed to a total of 60 individuals (22 Federal IT experts (11 National Ministery of ICT and 11 Ethio Telecom Experts), 4 Regional IT heads and 30 Regional IT Experts and 4 zonal ICT experts) but not all individuals completed and returned all the questionnaires. About 51 respondents (8 National Ministery of ICT and 8 Ethio Telecom expert, 4 Regional ICT Heads,27 Regional ICT experts, 4 Zonal ICT experts) filled the questionnaires and based on their responses, comparative analysis between the results of the survey and cloud XaaS architecture requirements identified from literature is described in the next section.

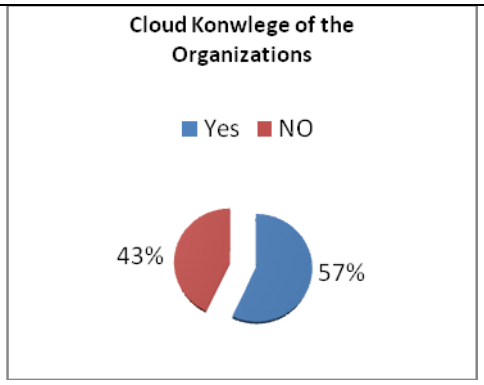
3.2 Data Analysis

This section provides overview of the research findings on Services available(applications and platform software used by the organizations), National and Regional data Centers infrastructure and compares them with the findings from literature review on cloud XaaS architecture requirements, and woredanet infrastructures capacity, policy and

frame work related to adoption of cloud computing is analyzed. The following questionnaires are developed and distributed to National ICT Ministery, Ethio Telecom, Oromia Regional State ICT Agency, Regional Bureaus ICT expert and Zonal ICT experts. The questionnaires is filled by all level of experts like Data Center, Network administrator, web master, application administrator and ICT managers. The conclusion of the responses is presented at end of the this section.

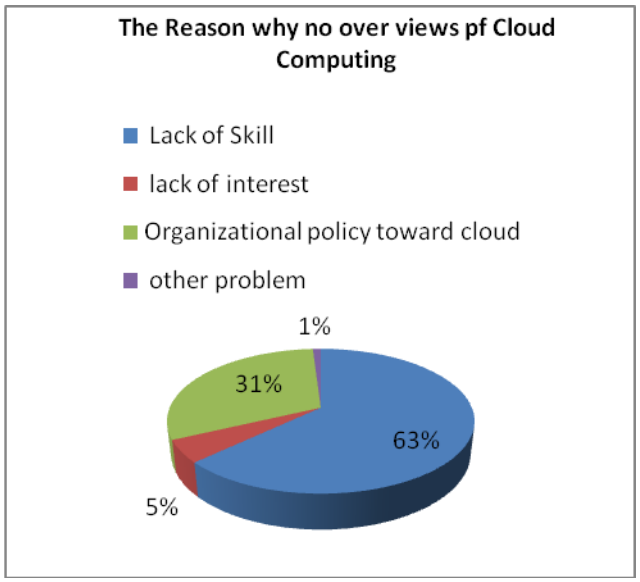
3.2.1 Views of Organizations towards Cloud Computing Technology Filled by Oromia ICT Agency and Ministry of Information Technology (NDC and OICTDA)

Table 3.1: Cloud Computing Overview (Respondents, N=35)

1. Do you have an overview of cloud computing?	Response Percent (from this study)	Cloud computing definition
a. ☐ Yes b. ☐ No		• Deep knowledge about cloud computing

In table 3.1, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this survey, it can be concluded that basic XaaS cloud computing overview exists in both Regional and national ICT sectors.

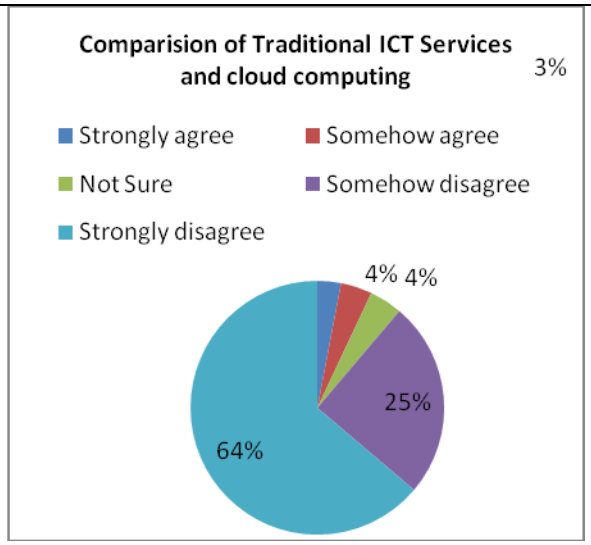
Table 3.2: The reason Why there is no cloud computing overview (Respondents, N=8)

2. *If your answer to question No 1 above is no, what is the reason?*	*Response Percent (from this study)*	*Lack of knowledge about cloud computing*
a. ☐ Lack of Skill b. ❑ lack of interest c. ☐ Organizational policy toward cloud d. ☐ other problem		• Lack of skill • Organizational policy towards cloud computing

In table 3.2, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this survey, it can be concluded those who don't have skill about cloud computing can be trained and ready for cloud computing adoption.

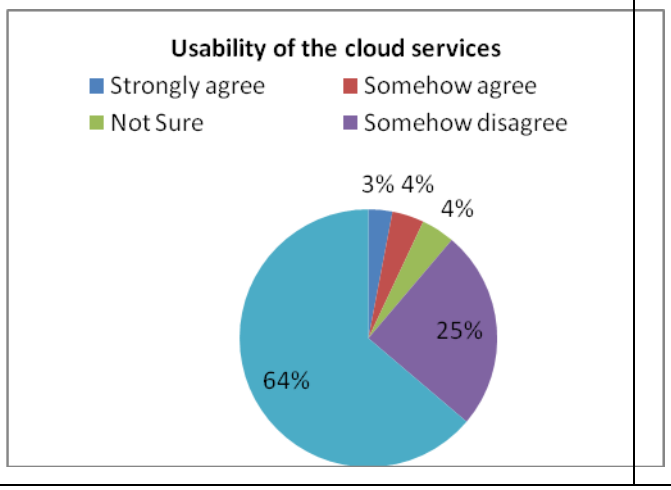
Table 3.3: Comparison of Traditional ICT services with Cloud XaaS Architecture Requirements (Respondents=43)

3. Do you think that services offered through the cloud necessarily more agile than traditional solutions?	**Response Percent (from this study)**	**Cloud computing advantages over traditional ICT services**

a. ☐Strongly agree b. ☐Somehow agree c. ☐Not Sure d. ☐Somehow disagree e. ☐Strongly disagree		• Implementing cloud computing is more agile than traditional ICT services

In table 3.3, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this survey, it can be concluded that implementation of cloud computing is more agile than traditional ICT Services

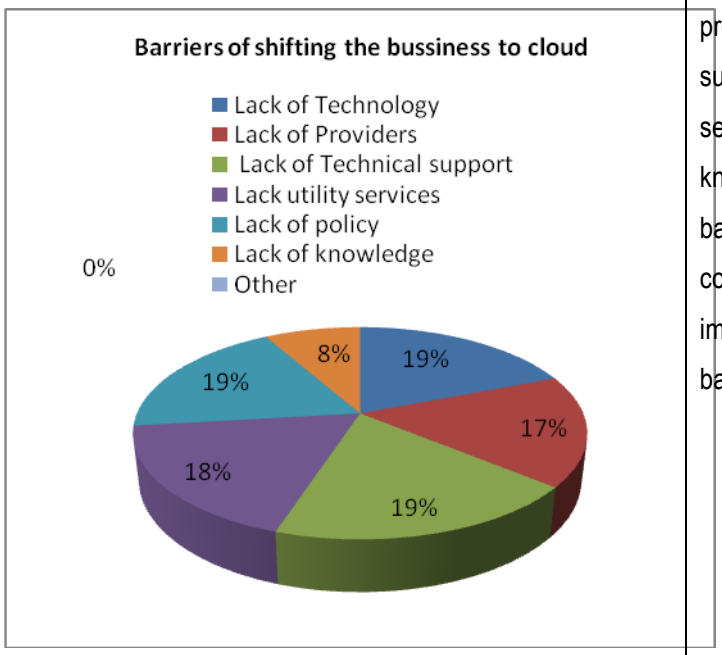
Table 3.4: Comparison of usability of cloud based services with Cloud XaaS Architecture Requirements (Respondents, N=43)

4. Does Usability of the cloud-based services affect your organizational working process if applicable?	**Response Percent (from this study)**	**Usability of cloud XaaS architectures requirements**
a. ☐ Strongly agree b. ☐Somehow agree c. ☐Not Sure d. ☐ Somehow disagree e. ☐Strongly disagree		• Strongly disagree of cloud computing don't affect working process

In table 3.4, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this survey, it can be concluded that usability of cloud computing is not affect working process.

Table 3.5: Barriers of shifting the business to cloud

(Respondents, N=43)

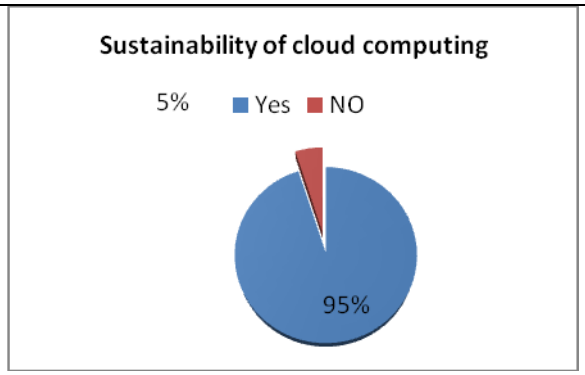
5. What are the barriers to effectively shifting the business to cloud services?	**Response Percent (from this study)**	**Barriers of shifting the business to cloud computing**
a. ☐Lack of Technology b. ☐Lack of Providers c. ☐ Lack of Technical support d. ☐Lack utility services e. ☐ Lack of policy f. ☐Lack of knowledge g. Other		Lack of knowledge , providers, technical support, utility services, policy and knowledge are barriers of cloud computing implementation barriers

In table 3.5, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this survey, it can be concluded that cloud computing implementations can be obstacle by Lack of knowledge , providers, technical support, utility services, policy and knowledge. But if there is a training given on the cloud adoption and usage, providers are available in the country the implementation should be achievable.

Table 3.6: Sustainability of cloud computing

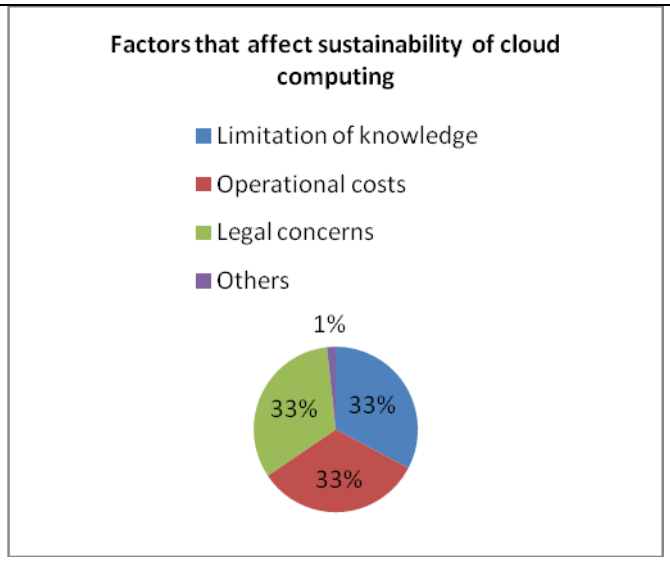
(Respondents, N=43)

6. Do you think that using cloud computing services a	**Response Percent (from this study)**	**Sustainability of cloud computing in views of**

sustainable business?		NDC and OICTDA Heads and Experts
a. ☐Yes b. ☐No		It is confirmed that the cloud computing business is sustainable

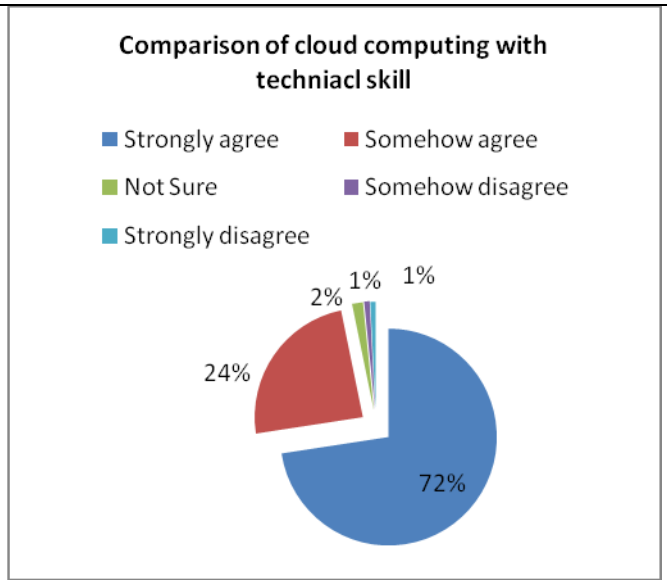
In table 3.6, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this survey, it can be concluded that cloud computing is a sustainable business when We apply XaaS.

Table 3.7 Factors that affect sustainability of cloud computing (Respondents, N = 9)

7. If NO, what are factors that make it unsustainable	Response Percent (from this study)	Factors that affect sustainability of cloud computing
a. ☐Limitation of knowledge b. ☐Operational costs c. ☐Legal concerns d. ☐ Others		Limitation of knowledge, Operational costs, legal concerns are factors that affect the sustainability of cloud computing

In table 3.7, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this survey, it can be concluded that limitations of knowledge, operational cost, legal concerns are major factors that affect the sustainability of XaaS.

Table 3.8: Comparison of technical skill with XaaS architecture adoption (Respondents=43)

8. Do you think that lack of technical skills (human capacity) slow down the usage of Cloud Computing in your organizations?	Response Percent (from this study)	XaaS Cloud Architecture Requirement
a. ☐ Strongly agree b. ☐ Somehow agree c. ☐ Not Sure d. ☐ Somehow disagree e. ☐ Strongly disagree		Technical skill can slow down the adoption of XaaS architectures

In table 38, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this survey, it can be concluded that technical skill can slow down the usage and adoption of cloud computing. By giving the training required for cloud computing can solve this problem.

9. Name skills that are critically lacking	Response Percent (from this study)	Shortage skill and cloud XaaS adoption comparison

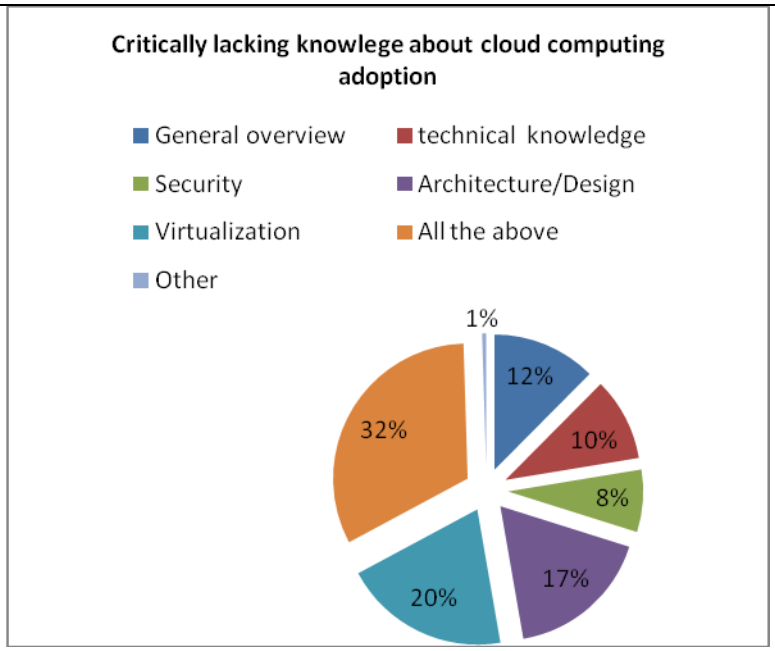
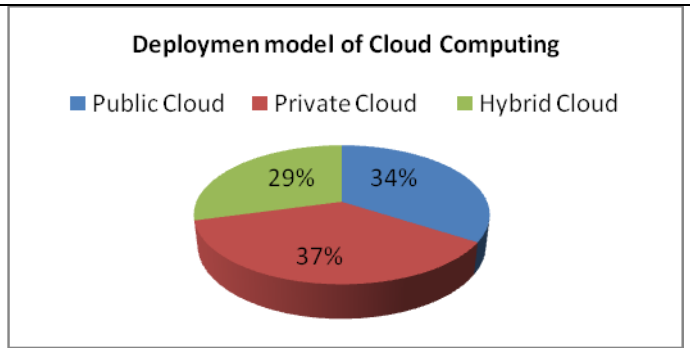
a. ☐ General overview b. ☐technical knowledge c. ☐Security d. ☐Architecture/Design e. ☐Virtualization f. ☐All the above g. ☐Other		Adoption of XaaS architecture can be affected by lack of skill like general over view, technical knowledge, security, architecture, virtualization.

Table 3.9: Shortage and skill and cloud XaaS adoption comparison (Respondents, N=43)

In table 3.9, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this survey, it can be concluded that, to adopt XaaS architecture all skill related to cloud computing is necessary .

Table 3.10: Deployment model Versus XaaS architecture adoption (Respondents, N=43)

10. If your organization willing to use or adopt cloud computing which deployment models want to use?	**Response Percent (from this study)**	**Deployment model of XaaS architectures**
a. ☐Public Cloud b. ☐Private Cloud c. ☐Hybrid Cloud		Private deployment model is preferable than others.

In table 3.10, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this survey, private cloud computing of deployment model of XaaS is preferable than others.

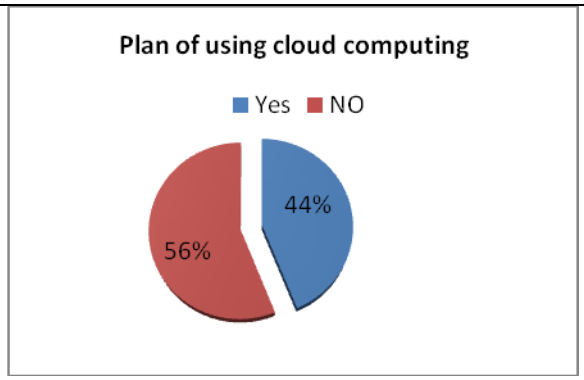
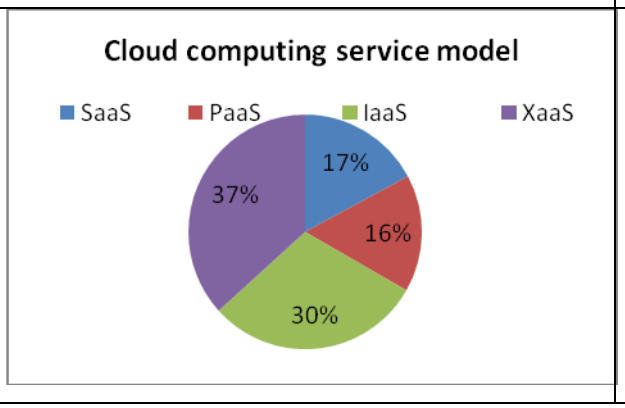
11. Do you have any plan to use cloud-computing services?	Response Percent (from this study)	Plan for XaaS architecture adoption
a. ☐Yes b. ☐No		Plan of the organizations to use cloud computing XaaS is higher

Table 3.11 Plan of the organizations towards XaaS architecture (Respondents, N=43)

In table 3.11, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, many organizations have plan to adopt XaaS.

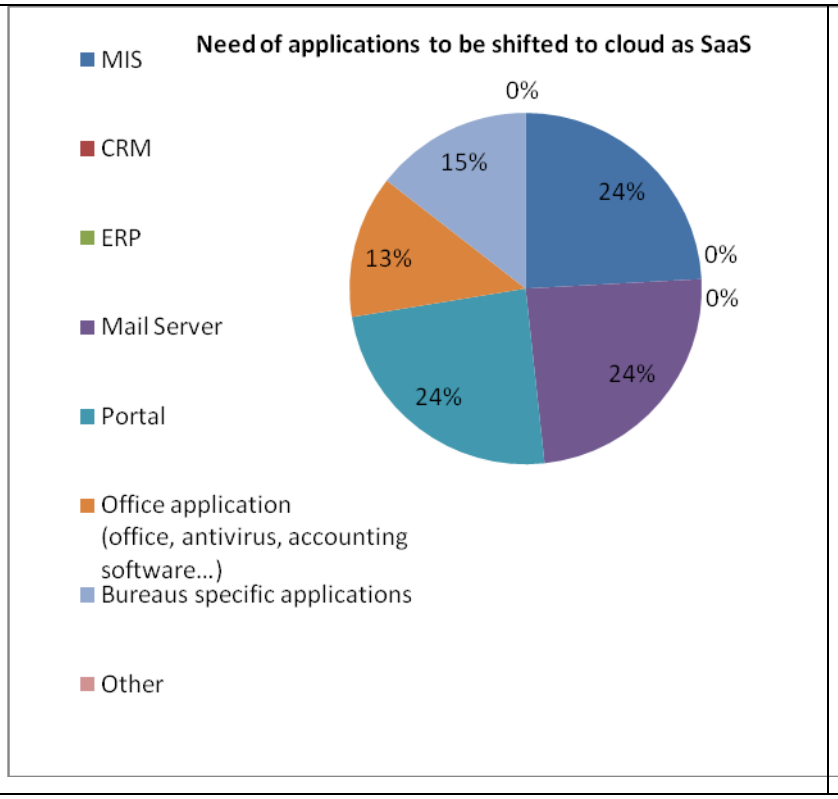
Table 3.12: Cloud computing service model adoption architecture (Respondents=43)

12. If your answer to question no 11 above is yes which service model you want to use?	Response Percent (from this study)	Service model of cloud computing adoption
a. ☐SaaS b. ☐PaaS c. ☐IaaS d. ☐XaaS		Every thin as a service is preferable than others to adopt

In table 3.12, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, XaaS adoption is selected by most of the organizations because they applications and infrastructure to shift to cloud.

Table 3.13: Shifting the applications to the cloud as SaaS (Respondents, N=43)

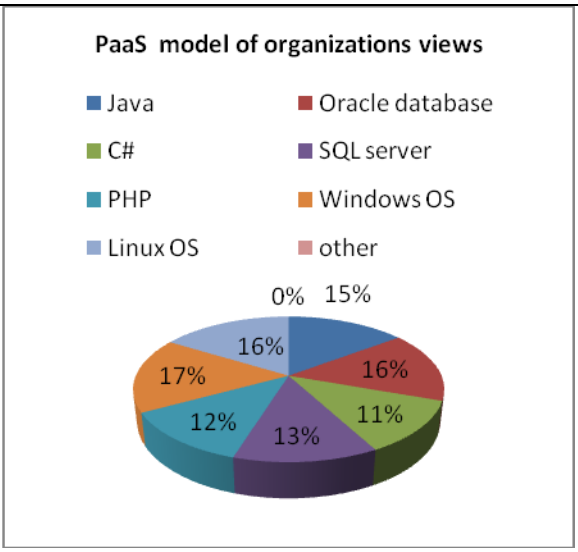
13. If you answer to question no 1 is SaaS, what are the services you want to deploy on cloud?	Response Percent (from this study)	SaaS deployment model architecture requirements

a. ☐MIS b. ☐CRM c. ☐ERP d. ☐Mail Server e. ☐Portal f. ☐Office application (office, antivirus, accounting software…) g. ☐Bureaus specific applications h. ☐Other		Applications to hosted on cloud computing are MIS, Mail Server, Portals, office applications and Bureaus specific applications

In table 3.13, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, the information collected from most of the offices shows that there is need of hosting the applications to the cloud.

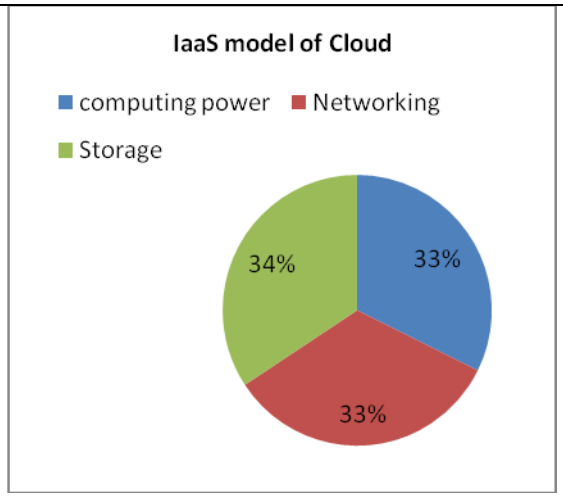
Table 3.14: Shifting the developer and Operating system software to the cloud (Respondents=43)

14. If you answer to question no 12 is PaaS, what are the services you want to deploy or access on/from cloud?	**Response Percent (from this study)**	**PaaS deployment models architecture requirements**

a. ☐Java b. ☐Oracle database c. ☐C# d. ☐SQL server e. ☐PHP f. ☐Windows OS g. ☐Linux OS h. other		Operating and developer software's like Java, C#, Oracle, php, Windows and many others are organizations need to shift to cloud

In table 3.14, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, the organizations are in need of many applications to host on cloud. This shows there is an idea of shifting the business to cloud and use of adopted XaaS cloud architectures.

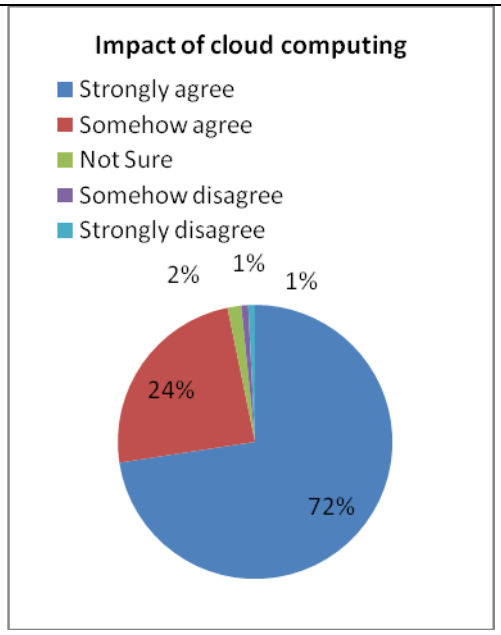
Table 3.15: Organizations need of IaaS cloud architectures (Respondents=43)

15. If you answer to question no 12 is IaaS, what are the services you want to deploy or access on/from cloud?	**Response Percent (from this study)**	**Cloud IaaS Architecture Requirement**
a. ❑computing power b. ❑Networking c. ❑Storage		The needs all of the components of IaaS components

In table 3.15, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, the organizations in need of IaaS models components like computing power, networking, storage.

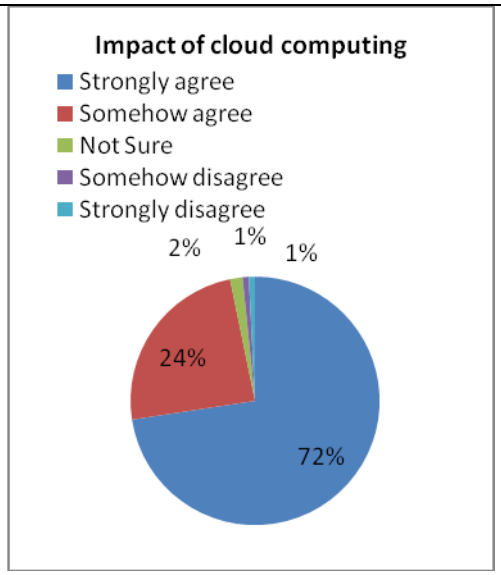
Generally, from the above three questionnaires we conclude that the organizations which fill this questionnaires in need of using the XaaS architecture if it is applied.

Table 3.16: Impact of cloud computing XaaS implementation on Work efficiency and effectiveness (Respondents=43)

16. Promoting cloud computing government offices significantly determines growth of service delivery and bringing the work efficiency and effectiveness.	**Response Percent (from this study)**	**Impact of XaaS on work efficiency and effectiveness**
a. ☐ Strongly agree b. ☐ Somehow agree c. ☐ Somehow disagree d. ☐ Strongly disagree e. ☐ Not Sure		The impact of organizational work efficiency is very high when we implement XaaS

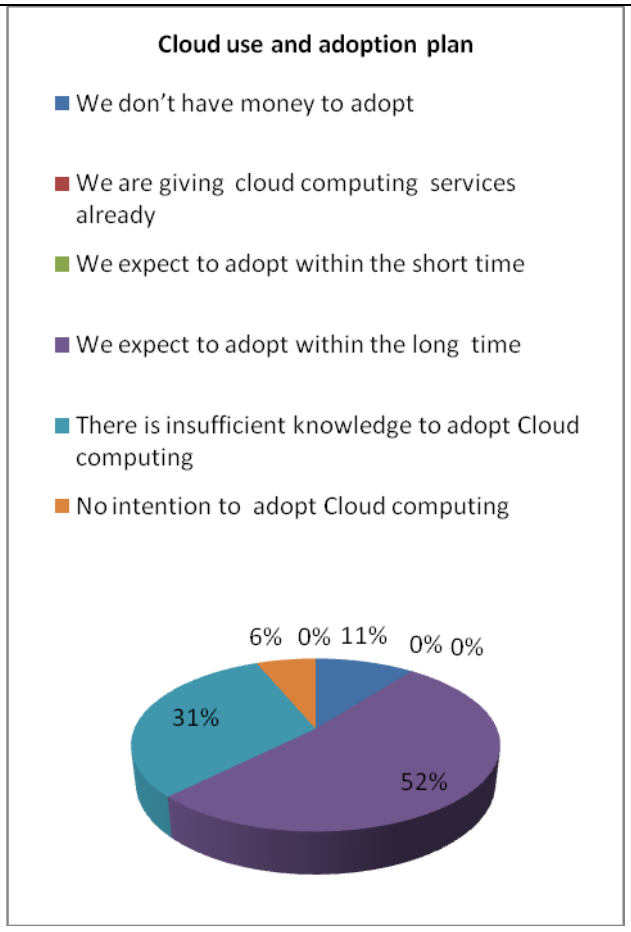
In table 3.16, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, implementations of XaaS is very crucial for the organization work efficiency and effectiveness.

Table 3.17: Impact of cloud computing XaaS implementation on Work efficiency and effectiveness (Respondents=43)

17. Promoting cloud computing government offices significantly determines growth of service delivery and bringing the work efficiency and effectiveness.	Response Percent (from this study)	Impact of XaaS on work efficiency and effectiveness
a. ☐ Strongly agree b. ☐ Somehow agree c. ☐ Somehow disagree d. ☐ Strongly disagree e. ☐ Not Sure		The impact of organizational work efficiency is very high when we implement XaaS

In table 3.17, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, implementations of XaaS is very crucial for the organization work efficiency and effectiveness.

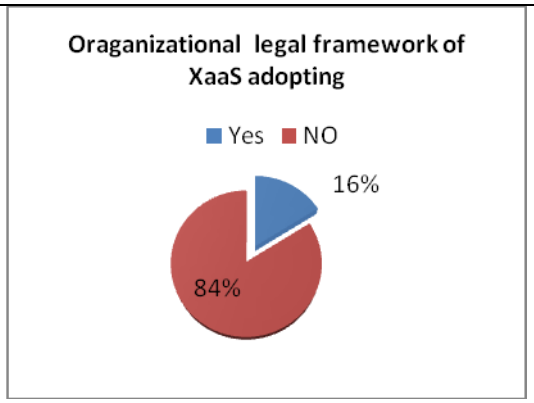
Table 3.18: Organizational need of XaaS for online services (Respondents=43)

18. Is your organization willing to use(adopt)cloud computing to give on line IT services?	Response Percent (from this study)	XaaS architecture of online services
a. ❑We don't have money to adopt b. ❑We are giving cloud computing services already c. ❑ We expect to adopt within the short time d. ❑We expect to adopt within the long time e. ❑ There is insufficient knowledge to adopt Cloud computing f. ❑No intention to adopt Cloud computing g. Others, Specify		Many organizations have plan of adopting and use of XaaS

In table 3.18, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, many organizations have plan of adopting and use of cloud computing XaaS architectures.

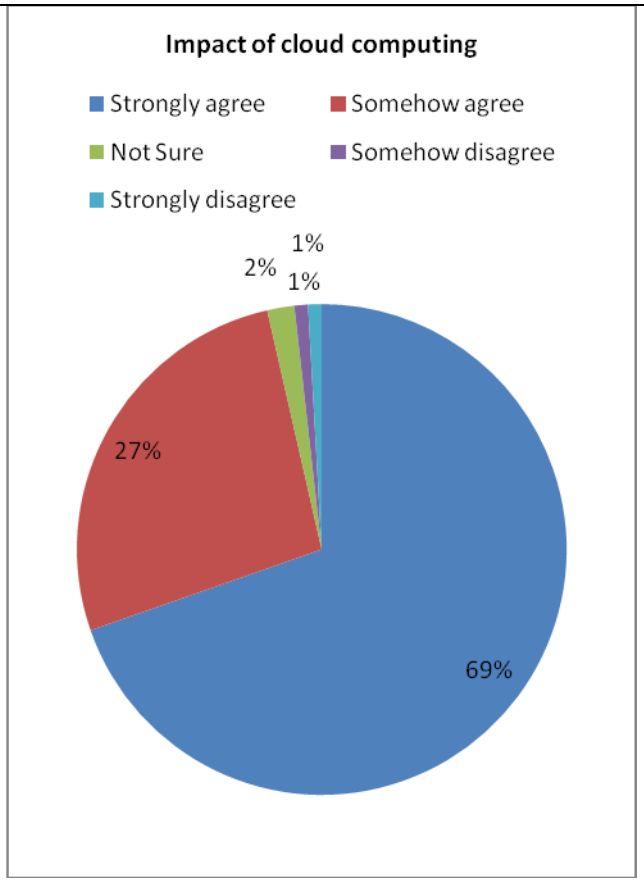
3.2.2 Views of Organizations towards Cloud Computing Legal Frame Works Filled by Oromia ICT Agency and Ministry of Information Technology (NDC and OICTDA)

Table 3.19: Evaluating Organizational legal framework towards XaaS Architectures adoption (Respondents=43)

19. Is there any policy that support adoption and use of cud computing?	**Response Percent (from this study)**	**XaaS architectures of Organizations**
a. ☐Yes b. ☐No		Even if no legal from work or adopting and Use of XaaS there is no legal policy that protect it.

In table 3.19, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, no legal framework does not mean that adopting and use of cloud is not protected. Like any other technology organizations can adopt and use of cloud computing.

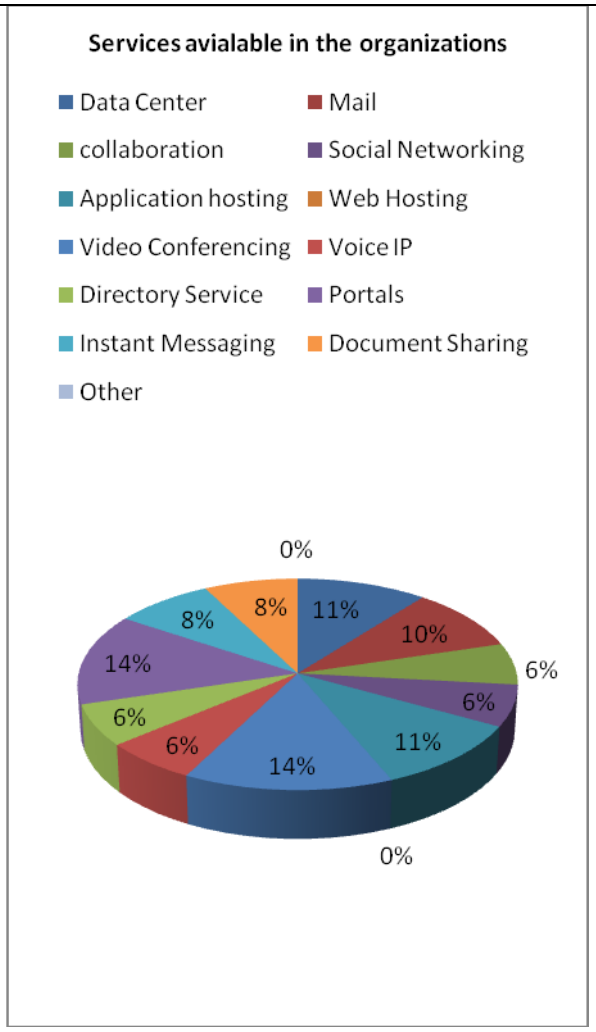
Table 3.20: Existing policy strength towards XaaS (Respondents=43)

20. If your answer to question No 1 is yes, Does the existing policy framework give you flexibility to exploit cloud computing as you wish?	Response Percent (from this study)	XaaS legal frame work
a. ☐Strongly agree b. ☐Somehow agree c. ☐ Not Sure d. ☐somehow disagree e. ☐Strongly disagree		Organizations strongly argue that the technology adoption policy is flexible that is similar o other technology adoption.

In table 3.20, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, Organizations strongly argue that the technology adoption policy is flexible that is similar o other technology adoption.

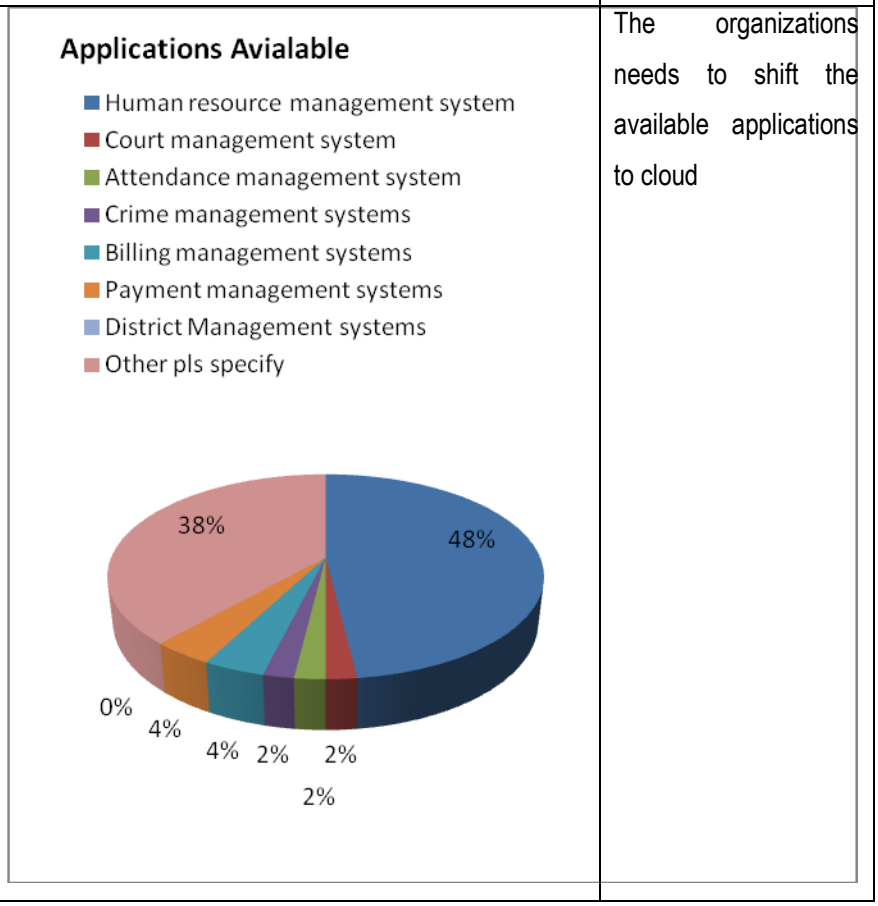
3.2.3 Organizational Traditional Work versus Cloud Computing Filled by Oromia ICT Agency and Ministry of Information Technology (NDC and OICTDA)

Table 3.21: Services available in the organizations (Respondents=43)

21. Which traditional ICT Services your organization offering? Pls tick all that apply)	Response Percent (from this study)	XaaS architecture requirements
a. ☐Data Center b. ☐Mail c. ☐collaboration e. ☐Social Networking f. ☐Application hosting g. ☐ Web Hosting h. ☐Video Conferencing i. ☐Voice IP j. ☐Directory Service k. ☐Portals l. ☐Instant Messaging m. ☐Document Sharing n. Other		Services available like portals, MIS and many other shows Pre requirements of XaaS for the organizations

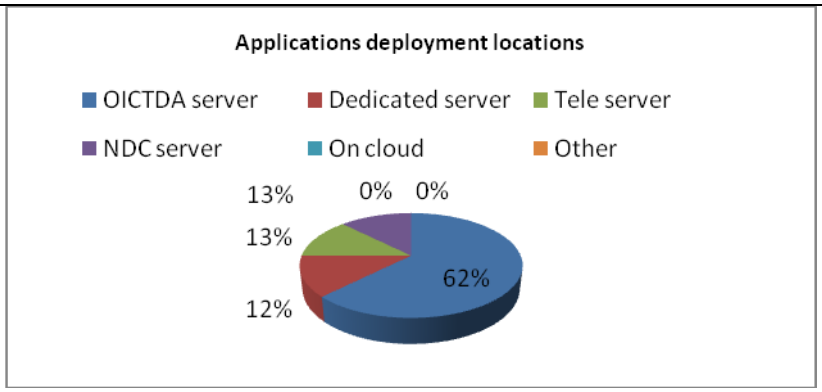
In table 3.21, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, this shows there are Infrastructures and software's that organizations can shift to cloud like XaaS models.

Table 3.22 comparison of applications with SaaS (Respondents=43)

22. Which one of the following applications developed and used by your organizations? (Pls tick all that apply)	Response Percent (from this study)	SaaS architecture requirements
a. ☐Human resource management system b. ☐Court management system c. ☐Attendance management system d. ☐Crime management systems e. ☐ Billing management systems f. ☐Payment management systems g. ☐District Management systems h. ☐Other pls specify		The organizations needs to shift the available applications to cloud

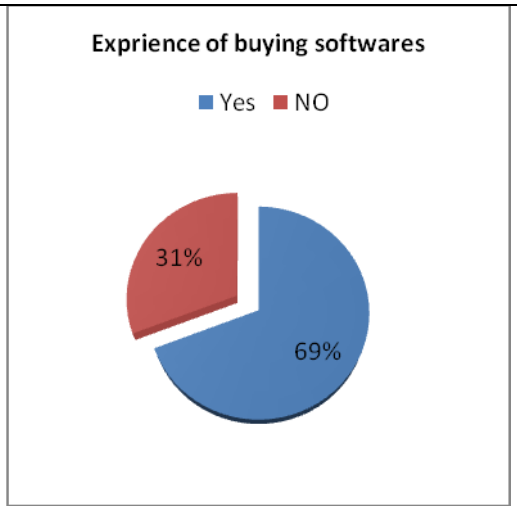
In table 3.22, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, there are applications available to be shifted to cloud.

Table 3.23: Deployment locations of applications available (Respondents=43)

23. If your organizations have an application, where do you deploy?	Response Percent (from this study)	XaaS architectures requirements
a. ☐ OICTDA server b. ☐ Dedicated server c. ☐ Tele server d. ☐ NDC server e. ❑ On cloud f. Other		No applications deployed on the cloud

In table 3.23, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers, from this we conclude that, most of the applications currently not deployed on the cloud.

Table 3.24: Experience of buying software (Respondents=43)

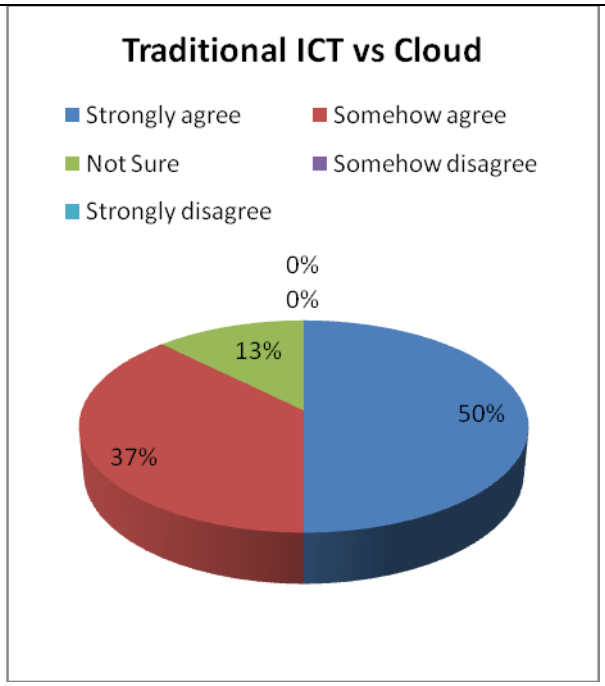
24. Do your organizations have experience of buying licensed software?	Response Percent (from this study)	Experience of buying software's
a. ☐ Yes b. ☐ No		Most of the organizations buy software's instead of using free

In table 3.24, 81.4% % respondents are from (Regional ICT Agency, Bureaus ICT expert and Zonal ICT expert), 18.6% respondents are from National ICT Ministers; from this we conclude that, there are organizations that buy software's.

3.2.4 Views of Ethiotelecom on Legal frame work, technology and institutions authority on cloud computing

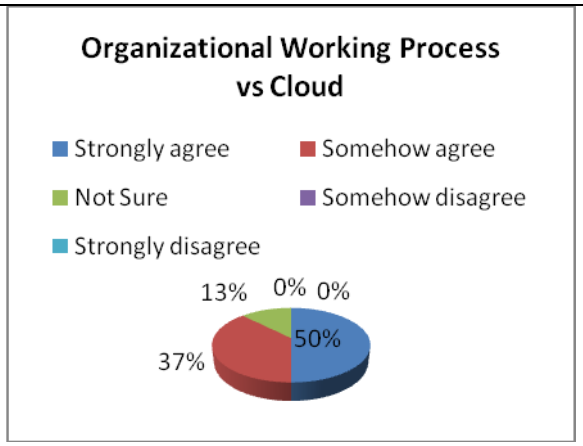
This section provides overview of the research findings on Ethio-Telecom Internet and Data services bandwidth capacity ,view on cloud computing and compares them with the findings from literature review on cloud IaaS architecture bandwidth requirement. The following questionaries are developed and distributed to Ethio-Telecom broadband internet services department IT professionals to know the type of internet and data services currently provided by Ethio-Telecom.The conclusion of the responses is presented at end of the this section.

Table 3.25: Traditional ICT services Versus Cloud Computing (Respondents=8)

1. Do you think that services offered through the cloud necessarily more agile than traditional solutions?	**Response Percent (from this study)**	**Traditional ICT services Vs Cloud**
a. ☐Strongly agree b. ☐Somehow agree c. ☐Not Sure d. ☐Somehow disagree e. ☐Strongly disagree		Cloud computing is more Agile than Traditional ICT

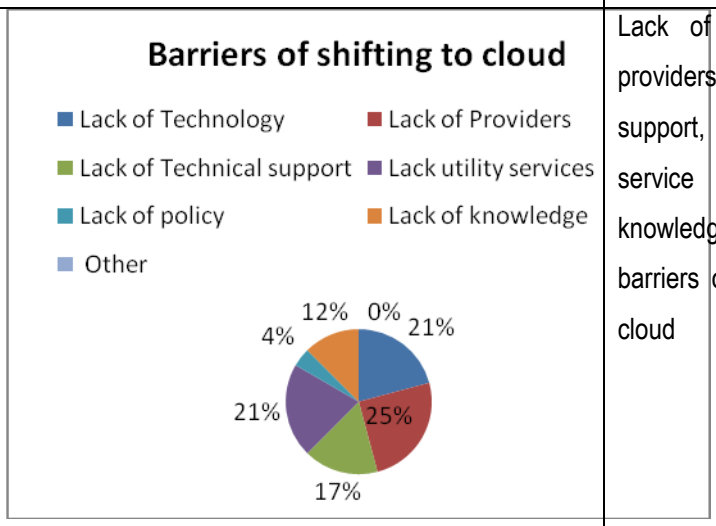
In table 3.25, 100% % respondents are from Ethiotelecom; from this we conclude that, Traditional ICT services are not agile than cloud computing, that adoption of XaaS is a basic issues.

Table 3.26: Organizational working process vs. Cloud computing (Respondents=8)

2. Does Usability of the cloud-based services affect your organizational working process if applicable?	Response Percent (from this study)	Cloud computing vs. Organizational Working Process
a. ☐ Strongly agree b. ☐ Somehow agree c. ☐ Not Sure d. ☐ Somehow disagree e. ☐ Strongly disagree		Most of the respondents are recommended that working process will change

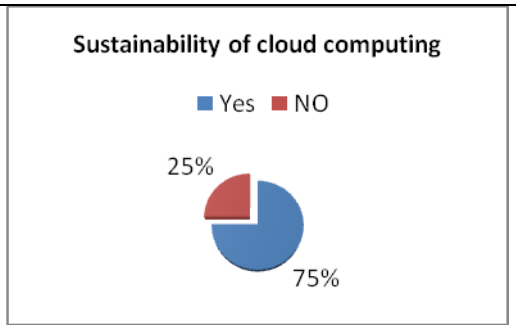
In table 3.26, 100% % respondents are from Ethiotelecom; from this we conclude that, working process of the organizations will change if cloud computing adoption applied.

Table 3.27: Barriers of shifting business to cloud (Respondents=8)

3. What are the barriers to effectively shifting the business to cloud services? *(select all that apply)*	Response Percent (from this study)	What are the barriers of cloud adoption
a. ☐ Lack of Technology b. ☐ Lack of Providers c. ☐ Lack of Technical support d. ☐ Lack utility services e. ☐ Lack of policy f. ☐ Lack of knowledge g. ☐ Other		Lack of technology, providers, technical support, policy, utility service and knowledge if the barriers of shifting to cloud

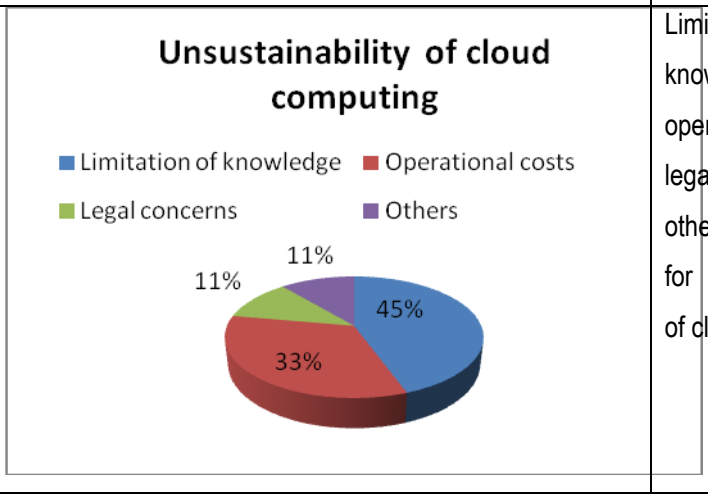
In table 3.27, 100% % respondents are from Ethiotelecom; from this we conclude that, Lack of technology, providers, technical support, policy, utility service and knowledge if the barriers of shifting to cloud. So , by providing this all services the cloud adoption might be applicable.

Table 3.28: Sustainability of cloud computing (Respondents=8)

4. Do you think that using cloud computing services a sustainable business?	**Response Percent (from this study)**	**Cloud computing sustainability**
a. ☐Yes b. ☐No		Most of the respondents are confirmed that the business is sustainable

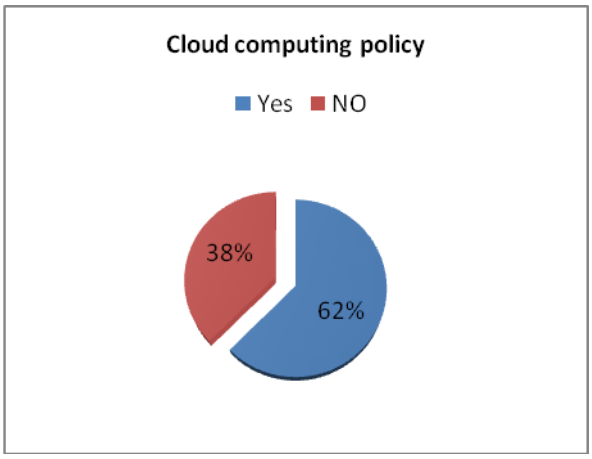
In table 3.28, 100% % respondents are from Ethiotelecom; from this we conclude that, cloud computing is a sustainable business.

Table 3.29: Factors that make cloud computing unsustainable (Respondents=8)

5. If NO, what are factors that make it unsustainable*(select all that apply)*	**Response Percent (from this study)**	**Factors that make cloud computing unsustainable**
a. ☐Limitation of knowledge b. ☐Operational costs c. ☐Legal concerns d. ☐ Others		Limitations of knowledge, operational costs, legal concerns and others are key issues for unsustainabbility of cloud computing

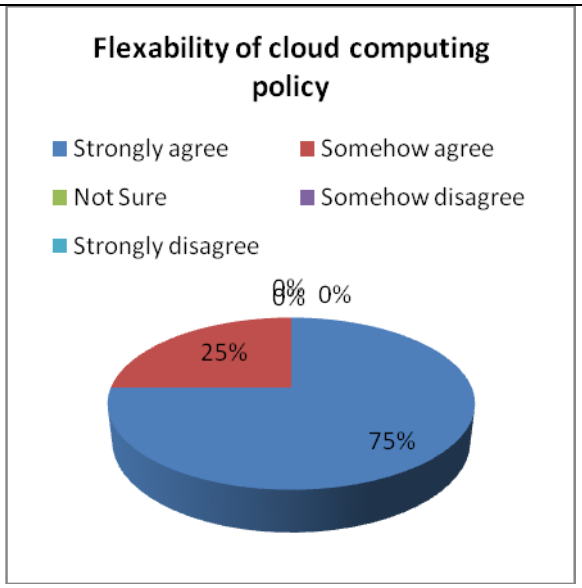
In table 3.29, 100% % respondents are from Ethiotelecom; from this we conclude that, cloud computing is unsustainable because of limitations of knowledge, operational cost , legal concerns and other issues.

Table 3.30: Existence of cloud adoption policy (Respondents=8)

6. Is there any policy that support adoption and use of cloud computing?	Response Percent (from this study)	Cloud computing adoption policy
a. ☐Yes b. ☐No		There is a policy that support cloud adoption

In table 3.30, 100% % respondents are from Ethiotelecom; from this we conclude that, there are policies that support cloud adoption in our country.

Table 3.31: Flexibility of cloud computing policy framework (Respondents=8)

7. If your answer to question No 1 is yes, does the existing policy framework give you flexibility to exploit cloud computing as you wish?	Response Percent (from this study)	Flexibility of cloud computing policy
a. ☐ Strongly agree b. ☐Somehow agree c. ☐ Not Sure d. ☐somehow disagree e. ☐Strongly disagree		From this the flexibility of cloud computing policy is high

In table 3.30, 100% % respondents are from Ethiotelecom; from this, we conclude that, there are policies that support cloud adoption and the policy itself flexible in our country.

3.3 Assessment and surveys analysis and Interpretations

We try to include targeted organizations and bodies for these questionnaires. We prepared many questionnaires but a few of questionnaires was not filled because of the person whose I gave the questioner have no time to fill. We analyzed the questionnaires of Oromia Regional State and National ministry of ICT. We case of Ethiotelecom I analyzed only questions that basic for this research.

Generally, from the analysis traditional ICT can be shifted to cloud without any problem if areas like cloud human resource, cloud technology and cloud providers are solved. XaaS is also can be applied from the analysis performed above.

Most of the organizations buy software's instead of using free software's. From the questionnaires Cloud computing is more Agile than Traditional ICT services which enable cloud to adopt. Most of the respondents are recommended that working process will change. Lack of technology, providers, technical support, policy, utility service and knowledge if the barriers of shifting to cloud. Many respondents are confirmed that the business is sustainable when cloud computing is adopted and used. Limitations of knowledge, operational costs, legal concerns and others are key issues for unsustainability of cloud computing. There is a policy that support cloud adoption in Ethiopia.

The impact of organizational work efficiency is very high when we implement XaaS. Many organizations have plan of adopting and use of XaaS. Even if no legal from work or adopting and Use of XaaS there is no legal policy that protects it. Organizations strongly argue that the technology adoption policy is flexible that is similar o other technology adoption. Services available like portals, MIS and many other shows Pre requirements of XaaS for the organizations. The organizations need to shift the available applications to cloud. Most of the organizations buy software's instead of using free.

Finally I used these findings from the targeted group to design new framework for XaaS in Oromia regional states. The result enables me to develop the framework without any boundary.

CHAPTER FOUR

4. Implementation

The cloud XaaS architecture that is going to be adopted will utilize the existing Ethiopian government ICT infrastructure and services available in Woredanet. As it is discussed in chapter one and chapter Two, Woredanet is an Ethiopian government private cloud. Private Cloud is one of the Cloud Computing deployment models, which provide the ability to access, manage and use resources of data centers in an efficient way. By applying cloud computing technologies like cloud XaaS architecture based on applications developed by the organizations and operating system software is that the organizations bought from the market, virtualization and consolidation of hardware resources like servers within data centers can be managed and used effectively. Using such a model allowed us to avoid venders' lock-in because it is owned and controlled by an organization itself.

In order to perform the adoption, the research first compares the different cloud XaaS architecture disused in the literature review, chapter 2, with existing components in Oromia Regional State ICT service delivery were discussed including applications and platform software's available. Datacenter infrastructures virtualizations technology was also discussed. Secondly, testing and demonstrations of everything as a Service in a small scale will be made. Third, the implementation of the adopted cloud XaaS architecture by scaling up for Ethiopian e-government services are proposed. Finally, other required elements and components of the cloud services beyond XaaS cloud service is discussed.

4.1 Comparison of Cloud XaaS Architectures by Parameters Set

The most powerful attribute of cloud XaaS architecture is the speed and simplicity with which pools of infrastructure resources, applications and operating system software's can be fixed and flexibly configured and reconfigured to match all requirements. We can deploy single cloud XaaS service software (Virtualization tools) in place of multiple different server configurations to satisfy varied application requirements for CPU, memory, network, and storage and quickly build our private cloud.

As indicated in the literature review the factors to be considered to adopt cloud XaaS architecture are ranked to indicate their level of significance. Based on our literature review each factor is given **low**- for low significant factor, **medium**-for medium significant factor and **high**-for highly significant factor. These factors are going to be used for comparing and analyzing the different venders' XaaS cloud architectures. A cloud XaaS architecture that considers factors that are highly significant is chosen and adopted in Oromia Regional government data center context.

Factor	Significance	Reason
Bandwidth	High	Highly related to our regional bandwidth consumption
Cost	High	Cost is very important for developing countries like Ethiopia
Performance	High	Performance and scalability is also basic parameters
Scalability	High	
Security	Medium	For this research security is not considered in detail
management	Medium	This parameter can be fixed after adoption
Integration with other Services	Low	When compared to others parameters they have little advantages
Standardization issue	Low	
Ease of Use	Low	
Compatibility with current Oromia data center hardware's	High	These is the basic for adopted framework

Table 4.1: Factors and their level of significance

Based on factors and their level of significance in table 4.1, for adopting cloud XaaS architecture in Oromia Regional data Center context, table 4.2, 4.3, 4.4 summarizes the comparison of the different venders' cloud XaaS (SaaS, IaaS and PaaS)architectures.

4.1.1 IaaS Management

Cisco UCS (Unified Computing Systems) Manager provides a single point of connectivity and management for all components in Cisco UCS, including both blade and rack servers. Cisco UCS Manager is embedded in a pair of Cisco UCS 6200 Series Fabric Interconnects in a highly available, active-standby clustered configuration running alongside the system's active-active data paths. This approach provides an important advantage over IBM and other traditional architectures: Cisco UCS Manager is a fully redundant management engine that is ready the moment the system receives power without the need for special clustering software or additional licensing fees. [48]

Cisco UCS uses model-based management in which Cisco UCS Manager discovers and inventories all system components and incorporates them into an object model. Server configuration occurs as a side effect of manipulation of the object model through the Cisco UCS Manager GUI, CLI, or XML API. This approach contrasts with the traditional approach, in which separate element managers configure every component separately and (hopefully) accurately. At best, traditional approaches support configuration through scripting. In contrast, Cisco UCS Manager orchestrates and automates server provisioning, device discovery, inventory, configuration, diagnostics, monitoring, fault detection, auditing, and statistics collection processes. Model-based management allows subject-matter experts to define policies for configuring specific types of servers. These policies can be embodied in Cisco UCS service profile templates, which can be used to generate Cisco UCS service profiles that can configure one or hundreds of

servers in minutes. Cisco UCS service profiles allow administrators to apply a different service profile to any server, providing extreme flexibility to respond to business workload peaks. This approach is the foundation of stateless computing, in which servers are ready to be configured for any workload on demand rather than needing to be purchased and configured for a specific workload, with significant barriers to repurposing.
IBM continues to use a model in which customers license management software and deploy a separate blade server for multi chassis management. [48]

The problem with traditional blades and with the HP Blade System architecture begins with the blade chassis itself. Rack-in-a-box blade architecture takes all the complexity of a rack (top-of-rack (ToR) switches, management modules, etc.) and squeezes it into every blade chassis. When you replicate this complexity multiple times per rack, you get even more complexity. In fact, you get far more complexity than a rack full of traditional servers with ToR switches. The HP Blade System architecture turns each chassis into an individual island that does not allow bandwidth to be shared outside each chassis. Changing applications or scaling resources requires you to reconsider the way that all components in the chassis are connected. Customers must determine when a new HP Virtual Connect module is necessary, what kind of We/O adapters is used on each affected blade, and whether or not recabling is required. Changing networking modules or updating blades to take advantage of new Intel architecture requires administrators to continually rethink and manage each island. HP's aging architecture limits flexibility and innovation in several ways: -Multiple local management modules are necessary and an external software overlay is required to present these individual components under a common interface sold at additional cost and multiple internal switching devices are necessary to connect each chassis to the outside world. This dependency, results in 2 switches for every 16 blades, or 1 switch for every 8 blades.[49]

4.1.2 IaaS Integration

Until the advent of Cisco UCS, integration of components into systems was a manual, time-consuming, error-prone activity that resulted in higher costs, configuration drift, and slower time to revenue. In creating a single converged system, Cisco used the concept of unified management to create a self-aware, self-integrating system in which every component can be configured through software rather than through manual processes. Cisco UCS service profiles capture every parameter needed to deploy a server (including personality, connectivity, configuration, and firmware), thus allowing servers to be configured for a particular application in minutes. The capability to provision any server in the system for any workload is called hardware-State abstraction, sometimes referred to as stateless computing. Cisco UCS unified management is supported through Cisco UCS Manager, an embedded management system that is available through an intuitive GUI, command-line interface (CLI), and XML API, making it easy for a wide range of ecosystem partners to integrate high-level processes (such as software provisioning) with the system's automated hardware configuration. Cisco UCS runs in the system's fabric interconnects and does not incur any additional licensing costs or the complexity of external management servers. [48]

Depending on an organizations' need, data within other cloud models such as public cloud can be accessed from private cloud. All venders' cloud IaaS architectures can support integration of data among private clouds or private to public clouds depending on an organization's data security policy. [48]

4.1.3 IaaS Performance

Cisco's exhaustive testing demonstrates that Cisco UCS decisively outperforms IBM Flex System in both east-west blade traffic latency and blade-to-blade virtual machine migration performance times. [48]

Cisco tested the Cisco UCS 5108 Blade Server Chassis with Cisco UCS 6200 Series Fabric Interconnects and compared this setup with the IBM Flex System with IBM Flex System Fabric CN4093 virtual fabric switch modules. Latency measurements were collected for two primary use cases: traffic between two servers within a single chassis and across multiple chassis. Cisco UCS demonstrates significantly lower latency when traffic spans multiple chassis, and lower server-to-server latency within a single chassis as packet sizes increase. Cisco UCS performed better because of Cisco network innovations embodied in custom application-specific integrated circuits (ASICs), helping ensure only one network hop between any two servers (rack or blade) in the same management domain. [48]

Cisco also recorded faster virtual machine migration times over a wide array of sizing and load conditions compared to the IBM virtual fabric. Cisco tested migration within a single chassis and across multiple chassis and found IBM migration times to be up to 92 percent higher than those for Cisco UCS, with Cisco UCS averaging 22 percent faster. This data was collected and averaged from hundreds of controlled test samples with identically configured servers. [48]

In addition to being a leader in enterprise networking, Cisco continues to demonstrate industry-leading performance, with over 70 world-record results on industry-standard benchmarks. More important, the east-west data results demonstrate the exceptional capability of the Cisco Unified Fabric design and the substantial gains that lead to better application performance [48]

With HP Blade System, traffic between each chassis must first travel through the local HP Virtual Connect modules, through an external ToR switch, and back through the second chassis' HP Virtual Connect module, resulting in three network hops and greater latency. Although HP refers to Virtual Connect as a module, it contains a switch application-specific integrated circuit (ASIC) that performs switching functions. Therefore, it is a switch.

Actual east-west traffic tests of these identically configured systems show that: -

- The HP Blade System c7000 with Virtual Connect has between 31 and 70 percent more latency than Cisco UCS. Cisco UCS demonstrated lower latency than the HP Blade System c7000 with Virtual Connect for every test case and every packet size (User Datagram Protocol [UDP], TCP, and TCP round-trip times).

- As packet sizes increased in each test, the HP Blade System c7000 with Virtual Connect disadvantage also increased compared to Cisco UCS [49]

4.1.4 IaaS Scalability

A single Cisco UCS management domain consists of up to 160 rack or blade servers and two Cisco fabric interconnects. For multi domain management, Cisco UCS Central Software can manage up to 10,000 servers in local or geographically dispersed data centers (providing global service profiles, statistics aggregation, and aggregated inventory). By enabling automation of processes, Cisco UCS unified management allows data center managers to achieve greater efficiency, agility, and scalability in their server operations while reducing complexity and risk. [48]

In Cisco, cloud IaaS architecture, scalability does not requires infrastructure change. Scaling is a plug-and-play operation. In Hp, Oracle and IBM cloud IaaS architectures scalability requires infrastructure change, which increases management overhead.

4.1.5 IaaS Cost

Cisco UCS is the only converged system that reduces overall amount of hardware and combines both blade and rack servers on a single unified fabric and management domain. Cisco's approach eliminates management and networking devices in every chassis, reducing the cost of powering, cooling, configuring, managing, monitoring, and maintaining the infrastructure. Cisco UCS places all management functions and configuration information in the fully redundant and highly available Cisco UCS Manager. Cisco Unified Fabric, with its wire-once capability, allows customers to scale their data centers easily, quickly, and efficiently without requiring a reevaluation of networking infrastructure every time servers are added. With Cisco UCS, the network is established once, with no changes necessary as it scales to 160 servers per domain (multiple domains with up to 10,000 servers can be managed with Cisco UCS Central Software).

IBM could have redesigned its blade server architecture with the IBM Flex Chassis platform. Instead of unifying networking and management, however, IBM replicated its traditional blade chassis architecture with blades in the front and networking switches and management modules in the back. IBM's minimum redundant configuration requires customers to purchase a pair of networking switches for every chassis. To meet this requirement, customers end up over provisioning and over purchasing hardware and port licenses. As a result of this approach, customers must purchase, configure, maintain, power, and cool one switch for every seven blades. Figure 2 illustrates the hardware consolidation and efficiency of a fully redundant Cisco UCS unified fabric compared to the traditional approach implemented by IBM. [48]

When an organization add additional servers, or move servers to a different location, an entirely new IBM cloud services management domain must be purchased. Except Cisco, other venders also follow the same principles as IBM with some cost variations.

HP's minimum redundant configuration requires customers to purchase a pair of networking switches for every chassis. Without the capability for each chassis to share We/O bandwidth, customers are forced to overprovision and over purchase hardware and port licenses every time they add another 16 blades. Customers must purchase, configure, maintain, power, and cool one switch for every 8 blades (two HP Virtual Connect modules per chassis)[49]

4.1.6 IaaS Ease of Use

Cisco cloud IaaS architecture is more flexible and less complex to use and manage. However, in Hp cloud IaaS architecture multiple layers of software required to use and manage the physical and virtual servers. Other venders also follow the same principle as HP cloud XaaS architecture.

4.1.7 IaaS Standardization

Cisco UCS Manager provides centralized management capabilities that serve as the system's central nervous system. Cisco UCS Manager provides flexible role- and policy-based management. Cisco UCS Manager maintains a model of the system that forms the single source of truth about all connected components. This model can easily be exported to configuration management databases (CMDBs) for use in ITIL processes.

Cisco UCS Manager provides system visibility to higher-level systems management and lifecycle tools from independent software vendors (ISVs), including Microsoft, BMC, CA, HP, and IBM. ISVs and in-house developers can use the Cisco UCS XML API to further customize and automate the system according to their unique requirements by using the Cisco go UCS Developer's Toolkit.

This capability is far beyond the reach of IBM's single-vendor approach, which requires customers to purchase additional IBM Smart Cloud software and IBM services to support hybrid cloud environments. Cisco offers an open management interface that increases choice; including cloud and management tools developed by Cisco and third party, open source, and user-developed ecosystems. [48]

4.1.8 IaaS Bandwidth

Unlike HP's network, in which bandwidth choices are made at deployment time and cannot be reconfigured without recabling the network, the Cisco UCS network is unified and bandwidth is shared dynamically. This approach provides more effective use of bandwidth and more headroom in the event that the application requires bandwidth from other modalities. Cisco UCS uses quality-of-service (QoS) controls to assign bandwidth priorities, and it enables your applications to dictate connectivity and bandwidth.[49]

Cisco UCS represents an advanced architecture based on Cisco innovation that uses a high-bandwidth, low-latency unified fabric for network and storage connectivity and server management. By using fabric interconnects as the single point of connectivity and management for the entire system, Cisco developed a single converged system that scales easily and efficiently while providing a superior level of fabric redundancy not found in IBM or other traditional architectures.[48]

Cloud IaaS Architectures from Literature Review	Parameters for Adopting Cloud IaaS architecture in Oromia Regional Data Center									
	Bandwidth Requirement	Cost	Performance	Scalability	Security	Management	Integration	Standardization	Ease of Use	Compatibility of Oromia data Center Hardware's
HP [31]	High	expensive	Greater latency	license	OK	Separate	OK	Vender Lock in	complex	Not Compatible
Cisco[34]	High	Less expensive	Lower latency	No license	OK	Unified	OK	Open	simple	Compatible
NIST[35]	High	expensive	Greater latency	license	OK	Separate	OK	Vender Lock in	complex	Not Compatible
Oracle [33]	High	expensive	Greater latency	license	OK	Separate	OK	Vender Lock in	complex	Not Compatible
IBM [29]	High	expensive	Greater latency	license	OK	Separate	OK	Vender Lock in	complex	Not Compatible

Table 4-2: Comparison of venders' cloud IaaS Architecture

Conclusion

Table 4.2 shows comparison of different cloud IaaS architectures based on factors to be considered before adopting the architecture.

According to comparison in table 4.2, factors that are significant to adopt cloud XaaS architecture were discussed. Venders' cloud XaaS architectures that considers these significant factors were compared. From the table, we can conclude that Cisco cloud IaaS architecture satisfies the factors that are significant to adopt cloud XaaS architecture. Therefore, It is preferable than other venders' cloud XaaS architecture to adopt in Oromia Regional State.

4.1.9 SaaS Management

To date, automated manageability has not been a priority for us because we have had relatively few applications and they have generally not been business-critical. Intel relies largely on user feedback and SaaS provider data to help Ensure the providers are meeting contractual obligations and addressing inadequacies.

4.1.10 SaaS Integration

Integration can be seen as the architecture which is adopted integrated with the applications available in Oromia Regional data centers.

4.1.11 SaaS Scalability

Scalable Multi-tenant usage can result in millions of users. Applications should be designed from the ground up to scale up and scale out and to be able to do this dynamically, on demand

4.1.12 SaaS Cost

Actually cost of the cloud provider is greater than the cost of applications available now. But this parameter only not taken as basics of criteria. In addition to cost other parameters is also considered.

Cloud SaaS Architectures from Literature Review	**Parameters for Adopting Cloud SaaS architecture**									
	Bandwidth Requirement	**Cost**	**Performance**	**Scalability**	**Security**	**Management**	**Integration**	**Standardization**	**Ease of Use**	**Compatibility of Oromia Applications**
NIST[35]	High	expensive	Greater latency	license	OK	Separate	OK	Vender Lock in	complex	Not Compatible
Intel[40]	High	expensive	Greater latency	license	OK	Separate	OK	Vender Lock in	complex	Yes
IBM[29]	High	expensive	Greater latency	license	OK	Separate	OK	Vender Lock in	complex	Not Compatible

Table 4-3: Comparison of venders' cloud SaaS Architecture

Conclusion

Table 4.3 shows comparison of different cloud SaaS architectures based on factors to be considered before adopting the architecture. Based on literature review section 2 these factors are used for comparing and analyzing the different venders' cloud SaaS architectures in addressing these factors.

According to comparison in table 4.3, factors that are significant to adopt cloud SaaS architecture were discussed. Venders' cloud SaaS architectures that considers these significant factors were compared. From the table, we can conclude that Intel cloud SaaS architecture satisfies the factors that are significant to adopt cloud SaaS architecture. Therefore, It is preferable than other venders' cloud SaaS architecture to adopt in Oromia Regional State.

4.1.13 PaaS Management

Management of tools available on the internet, which is provided by cloud, is very simple according to the literature reviews. The present software development cycle is very hard to handle. But if we shift to cloud everything is available through the internet.

4.1.14 PaaS Cost

PaaS has been shown to reduce costs by more than half, and in some cases improve return on investment (ROI) by more than 700 percent.

Cloud PaaS Architectures from Literature Review	Parameters for Adopting Cloud PaaS architecture									
	Bandwidth Requirement	Cost	Performance	Scalability	Security	Management	Integration	Standardization	Ease of Use	Compatibility of Oromia Software Development Tools
NIST[35]	High	expensive	Greater latency	license	OK	Separate	OK	Vender Lock in	complex	Not Compatible
IBM[34]	High	expensive	Greater latency	license	OK	Separate	OK	Vender Lock in	complex	Not Compatible
Oracle [33]	High	expensive	Greater latency	license	OK	Separate	OK	Vender Lock in	complex	Yes

Table 4-4: Comparison of venders' cloud PaaS Architecture

Conclusion

Table 4.4 shows comparison of different cloud PaaS architectures based on factors to be considered before adopting the architecture. Based on literature review section 2 these factors are used for comparing and analyzing the different venders' cloud PaaS architectures in addressing these factors.

Venders' cloud PaaS architectures that considers these significant factors were compared. From the table, we can conclude that Oracle cloud PaaS architecture satisfies the factors that are significant to adopt cloud PaaS architecture. Therefore, It is preferable than other venders' cloud PaaS architecture to adopt in Oromia Regional State.

4.2 Oromia Regional Data Center Existing Architecture (IaaS)

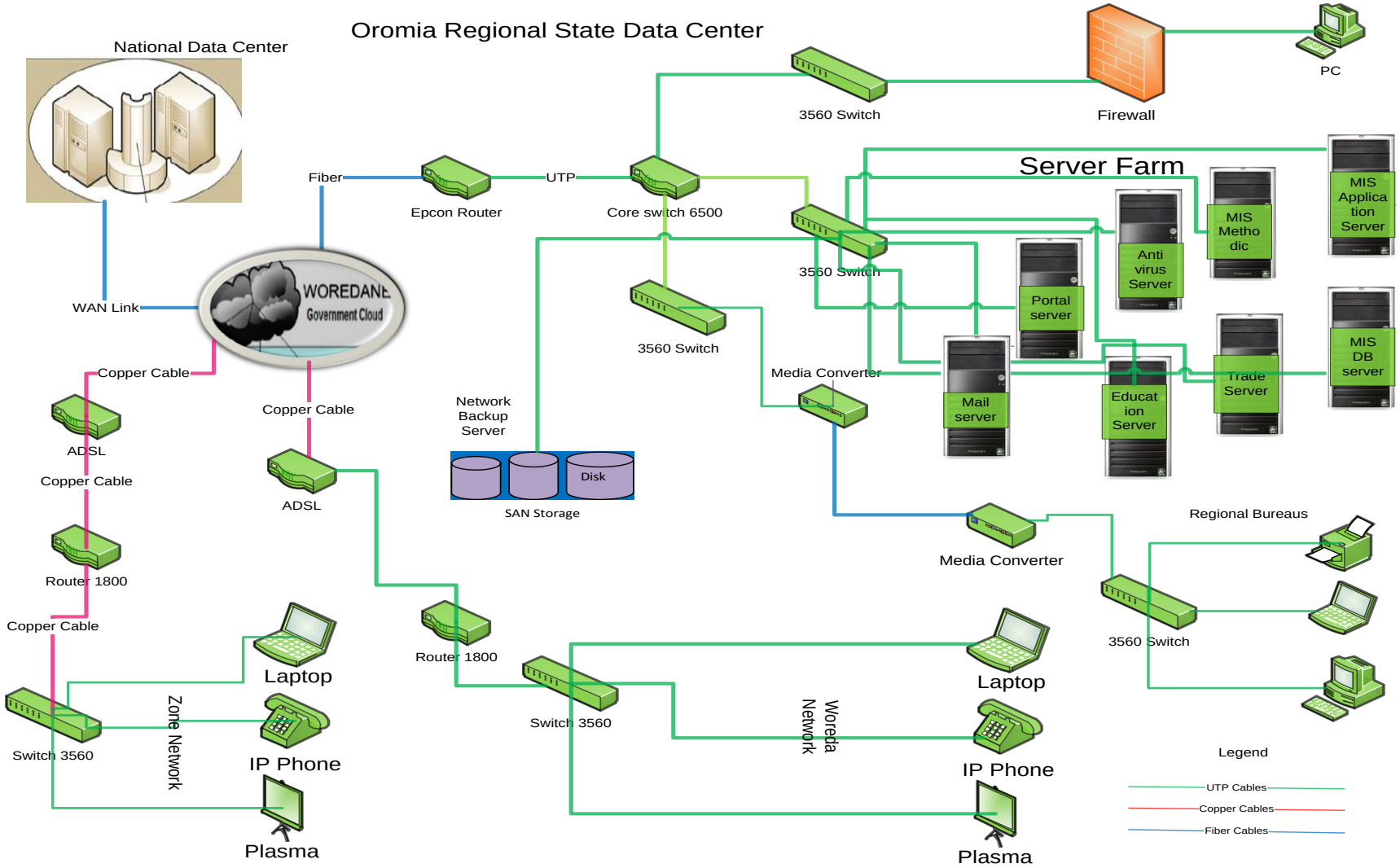


Figure.4.1: Oromia current data center architecture

4.2.1 Description of Components in Oromia Regional Data Center

In order to test the adopted Cisco cloud XaaS architecture, Oromia Regional Data Center is selected. The Data Center is found in Oromia ICT Development Agency in Addis Ababa, around "Sarbet". The Data Center is part of the Woredanet ICT network. EthioTelecom provided private IP Addresses for the National Data Center and Regional Data Centers. Currently e-government services like Video Conferencing, mail, internet and VoIP are being delivered from NDC and RDC to the respective Regional sates' public sectors that are connected to the woredanet. (Source: - interviews and agency report)

i. Oromia Regional Bureaus

Oromia Regional bureaus have many ICT equipments to deliver customer services. Equipments like Computers, printers, servers, Air Conditioners, laptops, scanners, routers, video conferencing equipments, switch, hub, firewall, storage device and other ICT equipments are used for efficient and effective service delivery. These equipments are purchased by each bureaus and Oromia ICT agency for free. Oromia ICT Agency also has in its data centers many network and storage devices which is purchased with high cost of many.

ii. Zone Government Offices

There are 18 zones and 12 administrative towns in Oromia. All of these 18 zones and administrative towns are using many equipments like Regional offices (Source:- interviews and agency report)

iii. Woreda/District Government Offices

There are 265 woredas in Oromia. About197 woredas are connected to NDC and Oromia RDC via woredanet network. The remaining 68 woredas are under progress to be connected to woredanet. These woredas is also using may devices like zone level offices (Source:- interviews and agency report)

iv. Equipments that are found in Oromia Regional Data Center

No	Name of Equipments	Number of Equipments	Cost per Unit	Total Cost
1.	Router 6500	2	550,000	1100000
2.	Swicth 2960	2	60,000	120,000
3.	Swicth 3560	3	28,000	84000

4.	**Hub**	**3**	**6,000**	**18,000**
5.	**Firewall**	**1**	**4,500,000**	**4,500,000**
6.	**Servers**	**8**	**200,000**	**1600000**
7.	**AC**	**1**	**Free gift**	**0**
8.	**CCTV Camera**	**1**	**Free Gift**	**0**
9.	**Plasma**	**1**	**40,000**	**40,000**
10.	**ZDTE Camera**	**1**	**400,000**	**400,000**
11.	**Rack**	**4**	**18,000**	**72000**
15.	**Computers**	**1**	**12,000**	**12,000**
16.	**Storage Devices**	**1**	**Free Gift**	**0**
17.	**Cost of Maintenance**			**150,000.00**
Total Cost				**7,946,000.00**
Over All Total Cost				**8,096,000.00**

Table 4-1: Equipments in Oromia Regional State Datacenters.[Source Oromia ICT Agency]

4.2.2 Equipments that are not existing in Oromia Regional Data Center

i. Software's

Virtualization Tools XenServer, XenCenter are not within Data Center. XenServer 6.5 host and XenCenter client application are used for this research. These virtualization tools are open source from Citrix Company.

ii. Hardware's

- **HBA (Host Bus Adapter) Card**

The virtualization of servers has become an important capability for most datacenters since the introduction of Fibre Channel Host Bus Adapters (HBAs). HBA brings datacenter infrastructure components to a higher level of performance and efficiency. It provides the physical (hardware) interface between the internal server bus and the external Fibre Channel SAN. HBAs also provide a logical (software) interface to the operating system [35].

- **Cisco Nexus 1000v VEM (Virtual Ethernet Switch)**

Cisco Nexus 1000V Series Switches are virtual machine access switches that are an intelligent software switch implementation based on IEEE 802.1Q standards. It supports server virtualization technology that gives network links connected to virtual machines the same status as physical links. This virtual network interface card (vNIC) feature improves performance and reduces NIC infrastructure. With the Cisco Nexus 1000V Series, we can have a consistent networking feature set and provisioning process all the way from the virtual machine access layer to the core of the data center network infrastructure. Virtual servers can now use the same network configuration, security policy, diagnostic tools, and operational models as their physical server counterparts attached to dedicated physical network ports [36].

- **Cisco Nexus 2100, Fabric Extender**

The Cisco nexus 2100 series fabric extender bring the unified fabric into the physical server enclosure, providing 10 Gigabit Ethernet connections between servers and the fabric interconnect, simplifying diagnostics, cabling, and management. It extends the We/O fabric by enabling FCoE (Fiber Channel over Ethernet) between the fabric interconnects and Server Chassis, enabling a lossless and deterministic fabric to connect all servers together. The fabric extender does not do any switching and it is managed as an extension of the fabric interconnects. This approach removes switching from the chassis, reducing overall infrastructure complexity and enabling the unified computing system to scale too many chassis without multiplying the number of switches needed, reducing costs and allowing all chassis to be managed as a single, highly available management domain [36].

Cost benefits Analysis of Cloud IaaS and Traditional Data Center[52]

	SD	ES	SC	IC	MM	SF	**Total**
Cloud IaaS	37632	47040	70962	117600	56448	**12600**	**342,282**
Traditional Data center Services	57600	115200	1,600,000	5184000	5760	**42000**	**7,004,560**

Hint

Strategic Decision, Selection of Computing Services and Types	SD
Evaluation and Selection of Service Provider	ES
Service Charge	SC

Implementation, Configuration, Integration and Migration	IC
Maintenance and Modification	MM
System Failure	SF

Table 4.2 :- Cost benefits Analysis of Cloud IaaS and Traditional Data Center[52]

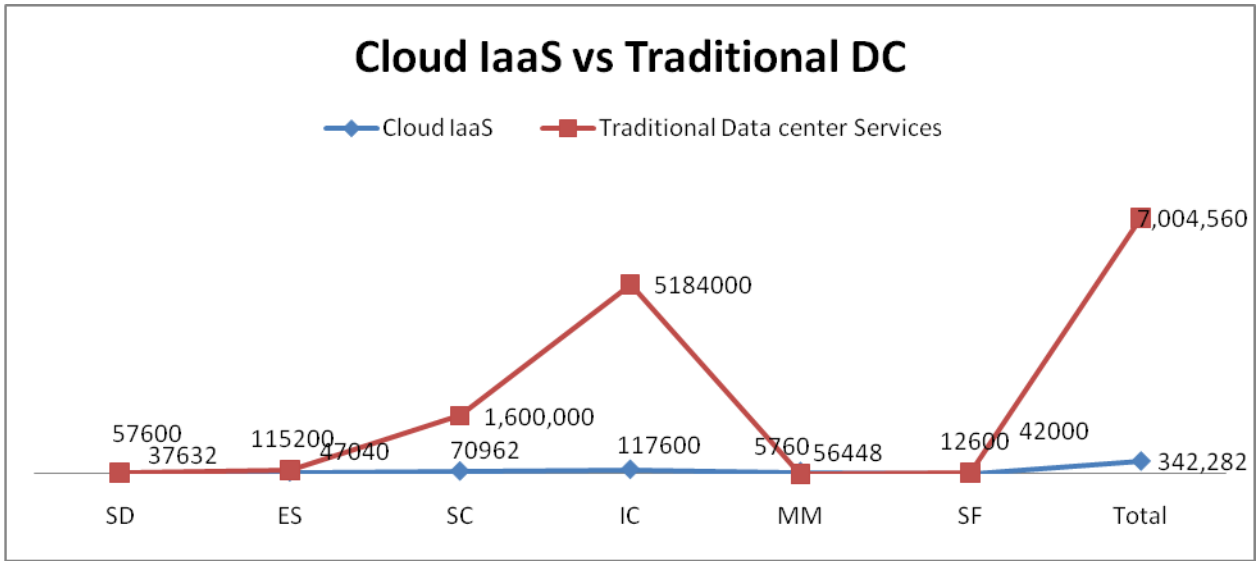


Figure 4.2:- Cloud IaaS Cost Vs Traditional DC Cost [52]

Descriptions of the Figure 4.5 [52]

Topics	Strategic Decision, Selection of Cloud Computing Services and Cloud Types	Evaluation and Selection of Service Provider	Service Charge IaaS	Implementation, Configuration, Integration and Migration	Maintenance and Modification	System Failure (fail)
Cloud Computing IaaS	Expenditure of time: - 16h*$112=$1,792 Information for decision making:- $140	Expenditure of time: - 12h*$112=$2,240	Computing power: - 10Month*$0.14*720hr+2month*$0.48*720 hr=$1412.6 Storage Capacity: - 1000GB*$0.14*12month=$1680 Out band data transfer: - 199GB*$0.12*12Month=$286.56	Expenditure of time: - 50hr*$112=$5600	Expenditure of time:- 2hr*$112*12month= $2688	Los per Periods:- $50*12month = $600

Traditional Computing of datacenters	Expenditure of time:-20days*24*4*30birr	Expenditure of time:-40*24*4*30	8servers*200000= 1,600,000	Expenditure of time: -60month*30days*24hr*4person*30birr	Expenditure of time:-2month*24*4person*30birr	Los per Periods:-12month*3500birr

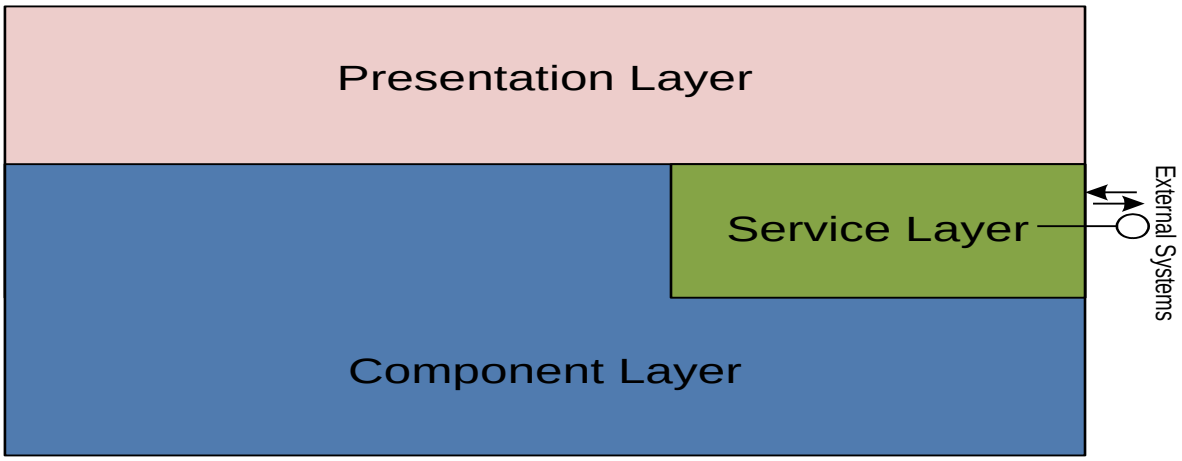
Table 4.3:- Descriptions of Table 4.6

4.3 Oromia Regional Software Development Existing Architecture (PaaS)

Oromia Regional State has developed many applications by two companies over the last six years. The application has developed by outsourcing to private companies like INSA and Methodic PLC. INSA has developed about 48 applications for 22 Regional bureaus. INSA 22 applications, which are now not ready for use, develop with 20 million Ethiopian birr without maintenance cost. The Methodic PLC is also developing application of 6 bureaus with 6 Million Ethiopian Birr. Both of them have used different tools of programming languages. [Source:-Oromia ICT Agency]

i. Applications Developed By INSA

INSA has developed MIS application for 22 Regional bureaus with JAVA programming Languages and Oracle database applications with the following Structures. It takes about four years to complete the applications. [Source:-



Oromia ICT Agency]

Figure 4.3 Insa Application Development Structures.[Source:-Oromia ICT Agency]

The module views of Document management System (DMS) developed for Regional bureau is with the following structure. This is DMS for four offices which performs document sent and received by the offices through Region, Zone and Woredas. [Source:-Oromia ICT Agency]

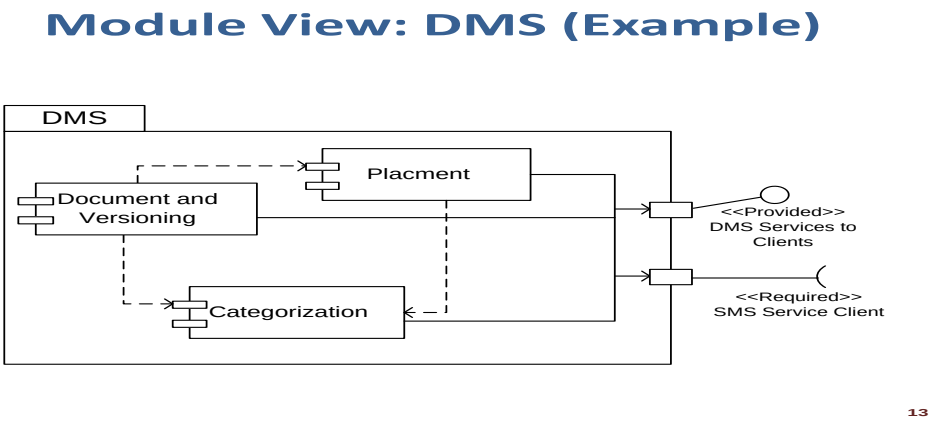


Figure 4.4 Insa Module Views of applications DMS

There is an also common system which is used by many Regional offices. Thus, this system is developed and deployed on one server then offices can browse and use with their respective account. [Source:-Oromia ICT Agency]

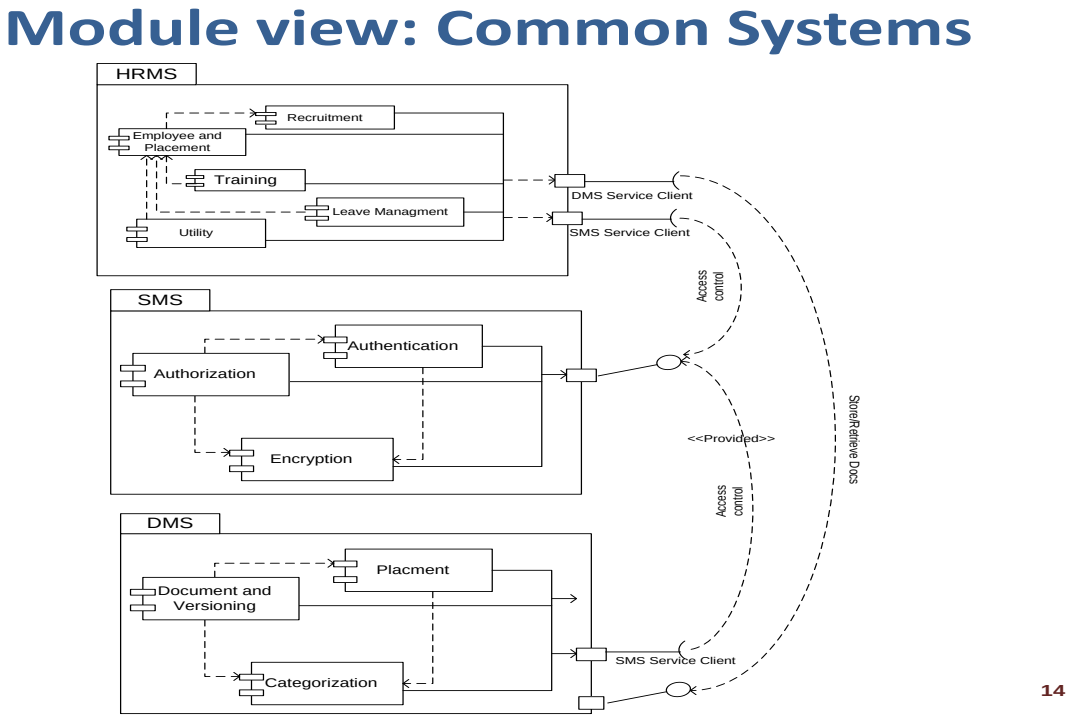


Figure 4.5 INSA Module Views of Common Systems

INSA is also developed web Portal for Oromia Regional State with cost of 100,000. Oromia Portal is one of Oromia BPR Automation project. It is new for our country especially in government level and has the objective of: Achieving the Regional government's vision of using information and communications technologies, providing easier access to government information and services for people, providing people with an overview of the Regional government a unified portal system.[Source:-Oromia ICT Agency]

ii. Applications Developed By Methodic Plc

Similar to INSA Oromia Regional State has also developed 6 bureaus MIS with C# and SQL Server 2008 database. This is also outsourced for external body for development. after company has also submitted the full source code and application. User training also given by the company. [Source:-Oromia ICT Agency]

iii. Applications Developed By Jimma University

Jimma University is one of the major partners of Oromia Regional State ICT Agency. With its internal experts Jimma University is also develop Mail server using open Source tools debian. Now Oromia Regional office using this mail server for sending and receiving documents and letters. [Source:-Oromia ICT Agency]

v. Applications Developed By OICTDA Experts

Two systems have been developed by Oromia Regional State experts. The first one is woredanet activities reporting systems which enable zone and woreda level experts to feed their report of monthly, quarterly and yearly report. This is done by C# and SQL server 2008 and deployed on one server and all level workers can get access to it. The second one is BSC (Balanced Score Card) automation system which is developed by OICT Agency Experts. [Source:-Oromia ICT Agency]

i. Analysis of PaaS In Case of Oromia ICT[Source:-Oromia ICT Agency]

No	*Name of Application*	*Developed by*	*Language used*	*Human Resource Involved*	*Cost*				*Total Cost*
					Developer and Training	Maintenance	Company cost	*Software*	
1.	Oromia BPR Automation of 20 Bureaus	INSA	Oracle and Java	20	1,000,000	3,000,000	20,000,000	100,000	24,100,000
2.	Oromia BPR Automation of 6 Bureaus	Methodic PLC	C# and SQL Server 2008	8	500,000	2,000,000	6,000,000	0	8,500,000

3.	Web Portal	INSA	Liferay	1	80,000	0	100,000	0	180,000
4.	Mail Server	Jimma University	Open Source Debian	1	25,000	0	0	0	25,000
5.	BSC Automation	OICTDA	Oracle and Java	8	650,000	0	0	0	650,000
6.	Woredanet reporting SW	OICTDA	C# and SQL Server 2008	8	150,000		0	0	150,000
								Over All Total Cost	**33,605,000.00**

Table 4-8: Analysis of Platform software's In Oromia Regional State Data centers [Source:-Oromia ICT Agency]

4.3.1 Minimum Software development Cost Performance

Minimum Software development Cost Performance[51]

	Setup	**Deployment**	**Maintenance**	**development**
Traditional Software development	5	5	5	50
Cloud Software development	2	3	80	5

Table 4.9:- Minimum Cost Performance Analysis [51]

Description

Table 4.9 describes about cost benefit analysis of PaaS vs. Traditional Software development. Sample cloud computing PaaS setup, deployment, maintenance and development is compared with Oromia datacenters software development life cycles. All the numeric data are from experience and compared with Oromia Regional State software development which is changed cost to 100%.

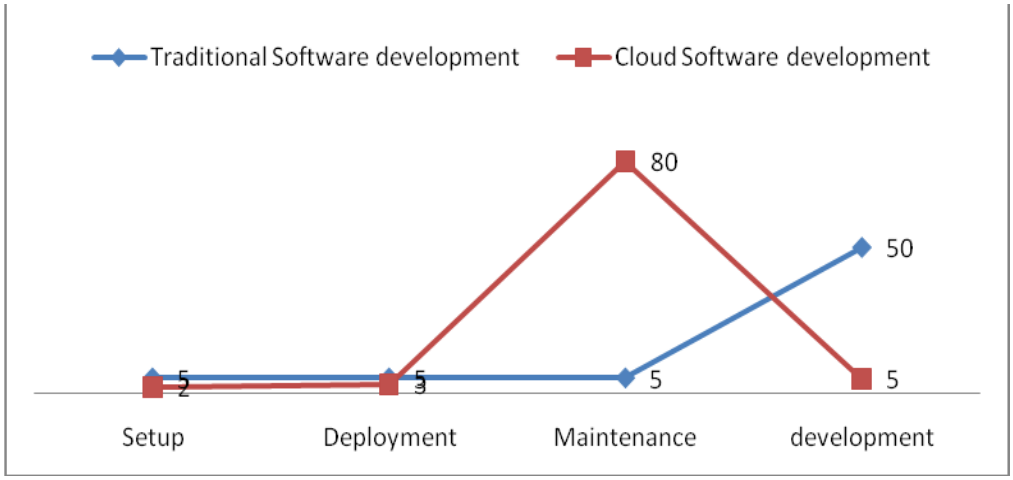


Figure 4.6:- Minimum Cost Performance Analysis [51]

Description

The Figure4.6 shown as three parameters. The parameters are setup, deployment, maintenance and development are compared with traditional and cloud PaaS. As we can see from the graph cost of Traditional software development is higher than Cloud PaaS.

4.3.2 Maximum Software development Cost Performance

Maximum Software development Cost Performance

	Setup	Deployment	Maintenance	development
Traditional Software development	20	15	15	80
Cloud Software development	5	5	90	10

Table 4.10:- Maximum Cost Performance Analysis [51]

Description

Table 4.10 describes about cost benefit analysis of PaaS vs. Traditional Software development. Sample cloud computing PaaS setup, deployment, maintenance and development is compared with Oromia datacenters software development life cycles. All the numeric data are from experience and compared with Oromia Regional State software development which is changed cost to 100%.

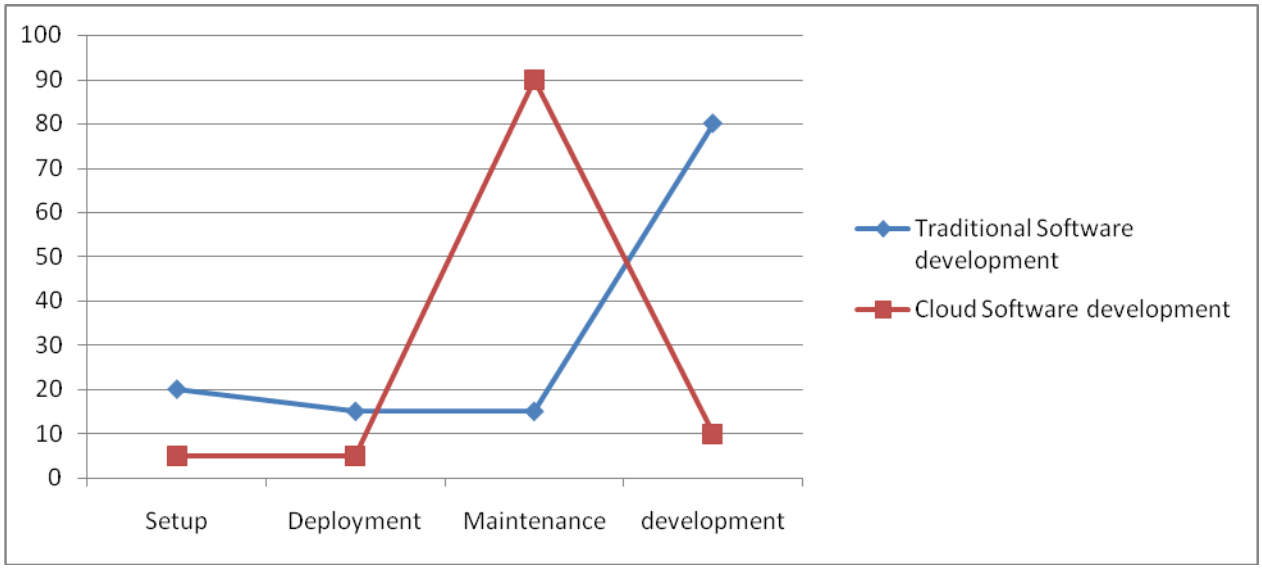


Figure 4.7:- Maximum Cost Performance Analysis [51]

Description

The Figure 4.7 are shown as three parameters. The parameters are setup, deployment, maintenance and development are compared with traditional and cloud PaaS. As we can see from the graph cost of Traditional software development is higher than Cloud PaaS.

4.3.3 Average Software development Cost Performance [51]

Average Software development Cost Performance

	Setup	Deployment	Maintenance	development
Traditional Software development	12.5	10	10	65
Cloud Software development	3.5	4	85	7.5

Table 4.11:- Average Cost Performance Analysis [51]

Description

Table 4.11 describes about cost benefit analysis of PaaS vs. Traditional Software development. Sample cloud computing PaaS setup, deployment, maintenance and development is compared with Oromia datacenters software development life cycles. All the numeric data are from experience and compared with Oromia Regional State software development which is changed cost to 100%.

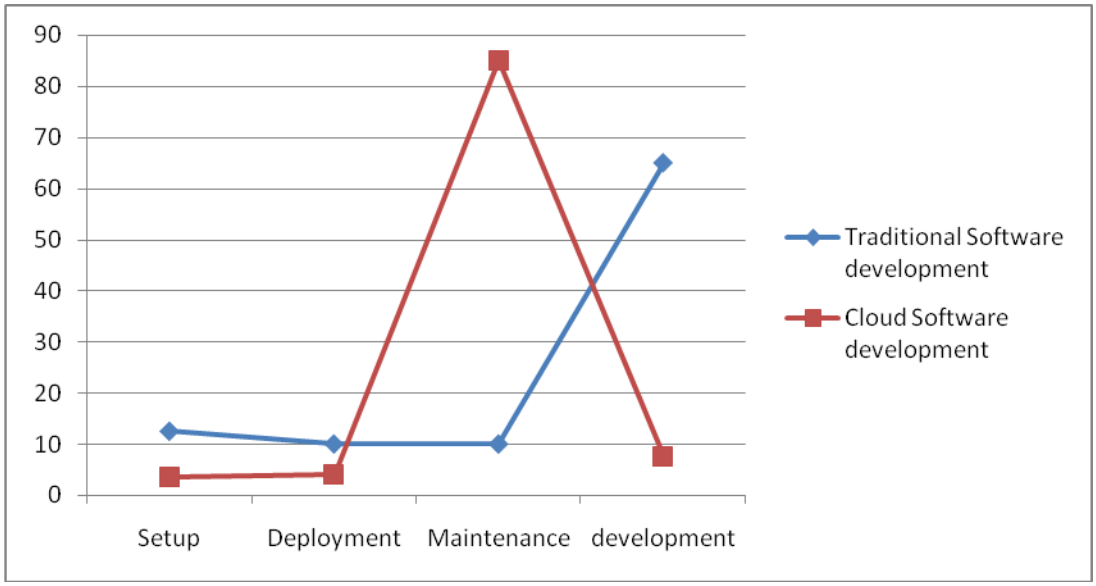


Figure 4.8 Average Cost Performance Analyses [51]

Description

The figure 4.8 is shown as three parameters. The parameters are setup, deployment, maintenance and development compared with traditional and cloud PaaS. As we can see from the graph cost of Traditional software development is higher than Cloud PaaS.

4.4 Oromia Regional Application Usage Existing Architecture (SaaS)

Many applications are used now by Oromia Regional ICT data centers and government organizations. Since the study is on Oromia ICT agency as case study, now we look at application, which are used by the Regional offices for daily activities. Most of the applications are free downloaded and available in the market with list cost. Only a few software's purchased by the agency and used for daily activities. External companies develop some of the software's used now, while few of them developed by agency experts internally. [Source:-Oromia ICT Agency]

No	Name Of applications	Problems on Usage	Cost	Licensed	Maintenance cost per year	Remark
1.	Office 2007	Attacked by virus	25	No	500	
2.	Antivirus	-	15	No	150	
3.	Windows	Attacked by virus	25	No	100	
4.	Power geez	Attacked by virus	20	No	0	

5.	IBX	Attacked by virus	Free	No	500	
6.	Portal	-	Free	No	50,000	
7.	Mail Server	-	Free	No	50,000	
8.	License Management System	Attacked by virus	Free	No	45,000	
9.	ORS(Oromia Reporting Software	Attacked by virus	Free	No	0	
10.	Adobe reader	Attacked by virus	Free	No	0	
11.	Browsers	Attacked by virus	Free	No	0	
12.	IDM	Attacked by virus	Free	No	0	
13.	Visio	Attacked by virus	20	No	0	
		Total Cost	**105.00**	**0**	**146,250.00**	
		Over all Total Cost	**146355.00**			

Table 4-12: Analysis of application software's In Oromia Regional State Data Centers[Source:-Oromia ICT Agency]

If we see the structure of applications software's used by the agency, no structures at all. Few of the application are installed and configured on the server then users can access it from internal and out of the offices. But, most of the applications are freely available and users can install on standalone pc and can use for public service delivery. Both of them have advantages and disadvantages. That means we can get the software's with minimum cost from the market and internet. The disadvantage is the applications are attacked by viruses and users can lose most of the time his file. [Source:-Oromia ICT Agency]

4.5 Adopted Cisco IaaS Architectures

The following figure shows the adopted CISCO IaaS architectures.

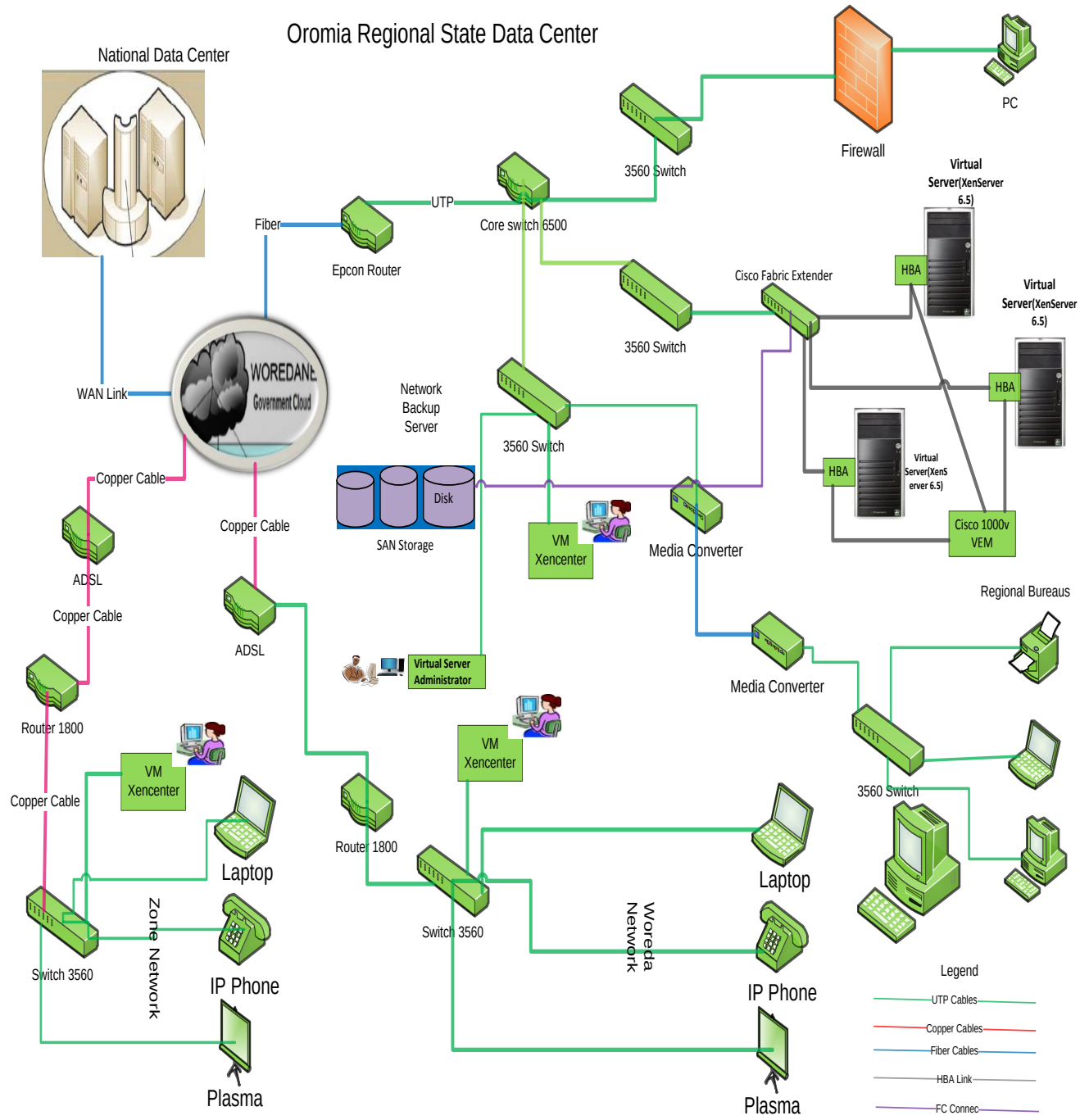


Figure 4.9: Adopted Cisco Architectures

4.5.1 Description of the Adopted Architecture

The figure above shows an overview of the adopted Cisco cloud XaaS architecture and how the subscribers/users from Regional bureaus, zones and woreda sectors offices could access servers resources within Oromia Regional Data Center via the Ethiopian government private Cloud , woredanet. It can be seen that the number of servers is decreased from 7 to 3 in new adopted architecture. Each physical server is installed XenServer 6.5 and the XenServer 6.5 can run 500 virtual machines. This shows that the 3 physical servers can run 1500 virtual machines which justify about 1500 users can connect and access the resources of the physical servers. Within six steps, the user can use a resource and then release it. These steps are illustrated in the following.

- The user sends a request using the XenCenter client interface installed on his/her desktop computer
- The verification of the users will be checked using the built-in Active Directory feature in XenServer 6.5 which is configured by Administrator.
- If the user is unauthorized to request such services, the system will reject the user's request; otherwise, the request will be sent to the virtual infrastructure manager XenServer 6.5 to redirect the request to the appropriate services
- The system will establish a connection between the requested service from the Cloud and the user.
- As long as the user needs the resource and does not exceed the maximum usage period, the system synchronizes the service delivery between the user and the resource.
- When the user is done and no longer needs the requested resource, the system will terminate the session and disconnect the user from cloud service.

4.5.2 Access to storage is done as follows

In the XenServer 6.5 Storage Repository, Virtual Disk Images are created as a storage abstraction of objects that can be presented to a Virtual Machine. A Storage Repository is an abstraction of the physical disk device, which can be either a local device or a device on a SAN. To do this,

- The Storage Repository connects to the block-based devices that are located on a local machine, a SAN or anywhere else, using XenServer’s Physical Block Devices connector object.
- Based on the Virtual Disk Image, storage can be presented to the VM.
- This storage is offered as a Virtual Block Device connector object, which is seen by the VM as its virtual disk.

4.6 Adopted Oracle PaaS Architectures

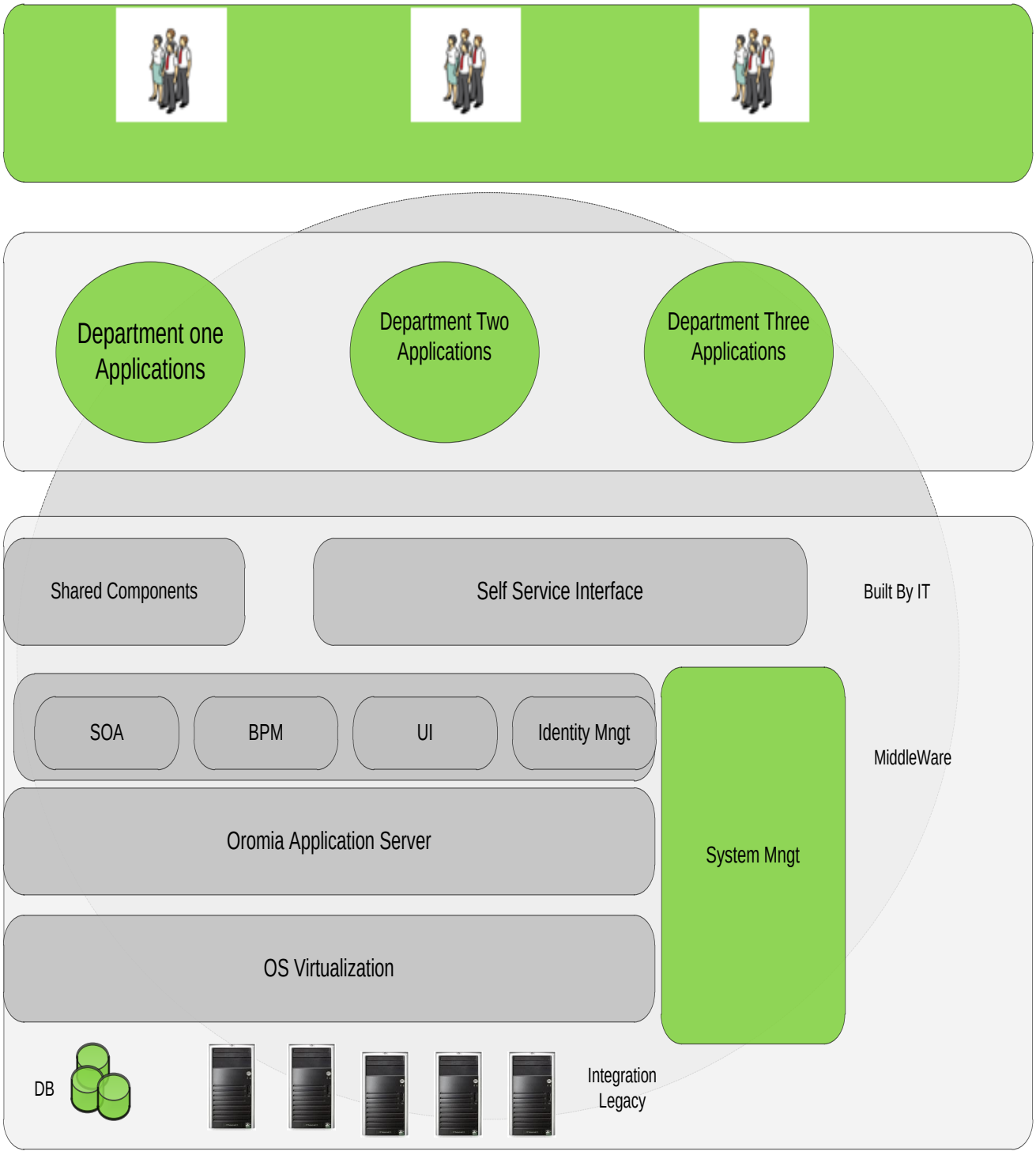


Figure 4.10 Adopted Oracle PaaS Architectures

The physical infrastructure includes servers, legacy systems such as mainframes, integrations, and database resources. Service-oriented architecture (SOA), with its approach of modularizing applications into reusable components accessible through standardized interfaces using XML, SOAP, and the various specifications, is the obvious starting point. In addition to SOA components, many enterprises will want to include business process components managed within a unified BPM framework as part of their PaaS.

Process Manager provides the federation capability to create process components out of new as well as legacy assets while also supporting the flexibility to enable multiple departments to incorporate PaaS-based BPEL components into their respective workflows. A high-priority concern for many enterprises in creating a private cloud is security. Particularly for firms in domains with a high level of regulation and/or sensitive customer data, cloud's self service can be a significant challenge. Balancing rich mechanisms for identity and access management with convenience features such as single sign-on is a must for cloud environments. Systems management is a characteristic that depends partly on functionality manifested in a particular software utility.

Each department applications tools are interacted and accessed by department legal users. Applications tools that are available in Oromia Regional State data center are stored in application servers and the database server is also available for storage.

4.8 Adopted Intel SaaS Architectures

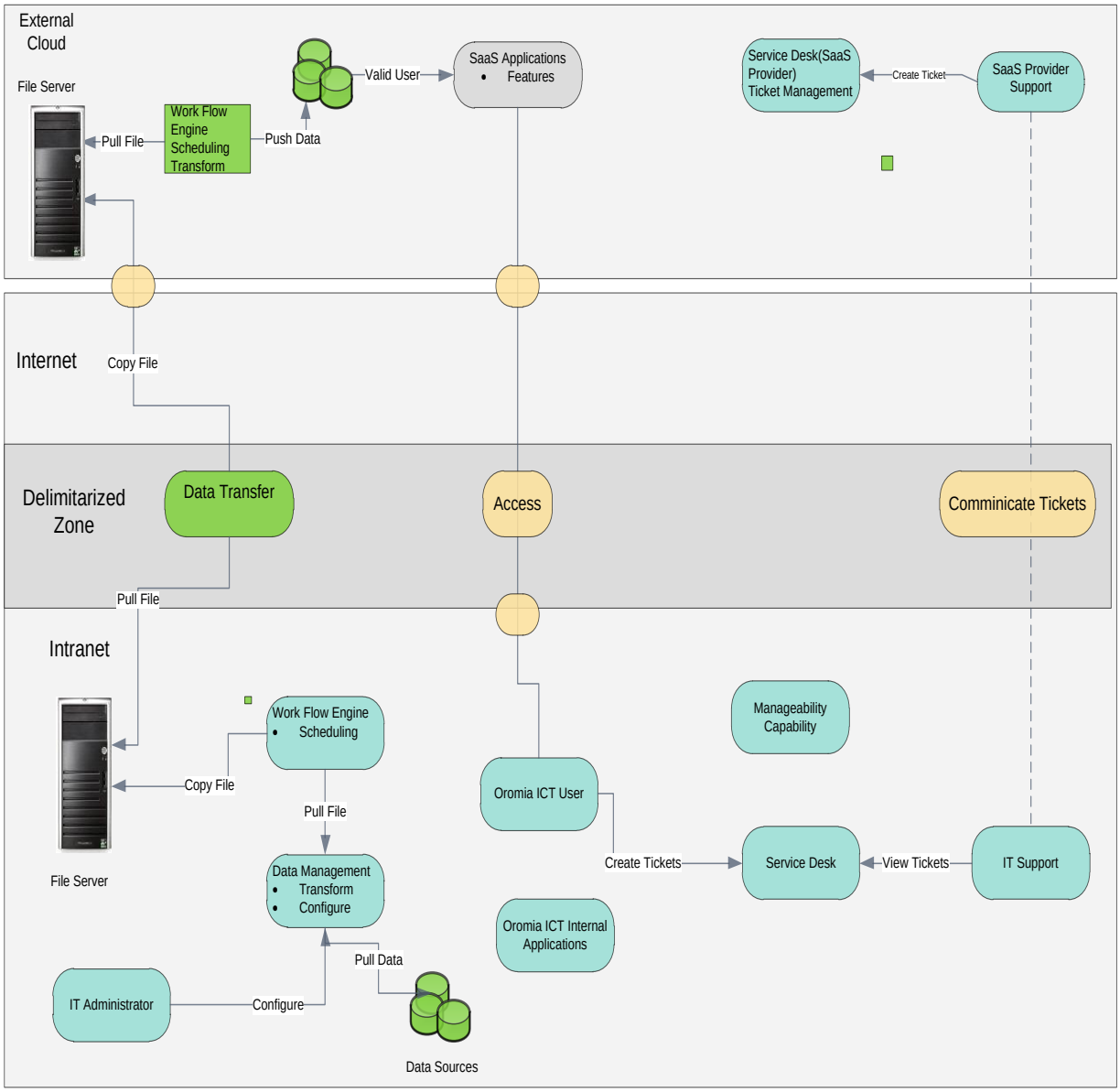


Figure 4.11 Adopted SaaS Architectures

This structure explains about three tires. The first is linkage of external cloud which contains file servers are accessed by valid users. To enhance these SaaS applications features are added to the architectures. Using internet data can be accessed from demilitarized zone. The demilitarized zone is Oromia Regional State data center application storage which is provided to the cloud.

There is also intranet zone which contains file servers, oromia It internal applications and others.

4.9 Adopted XaaS Architectures

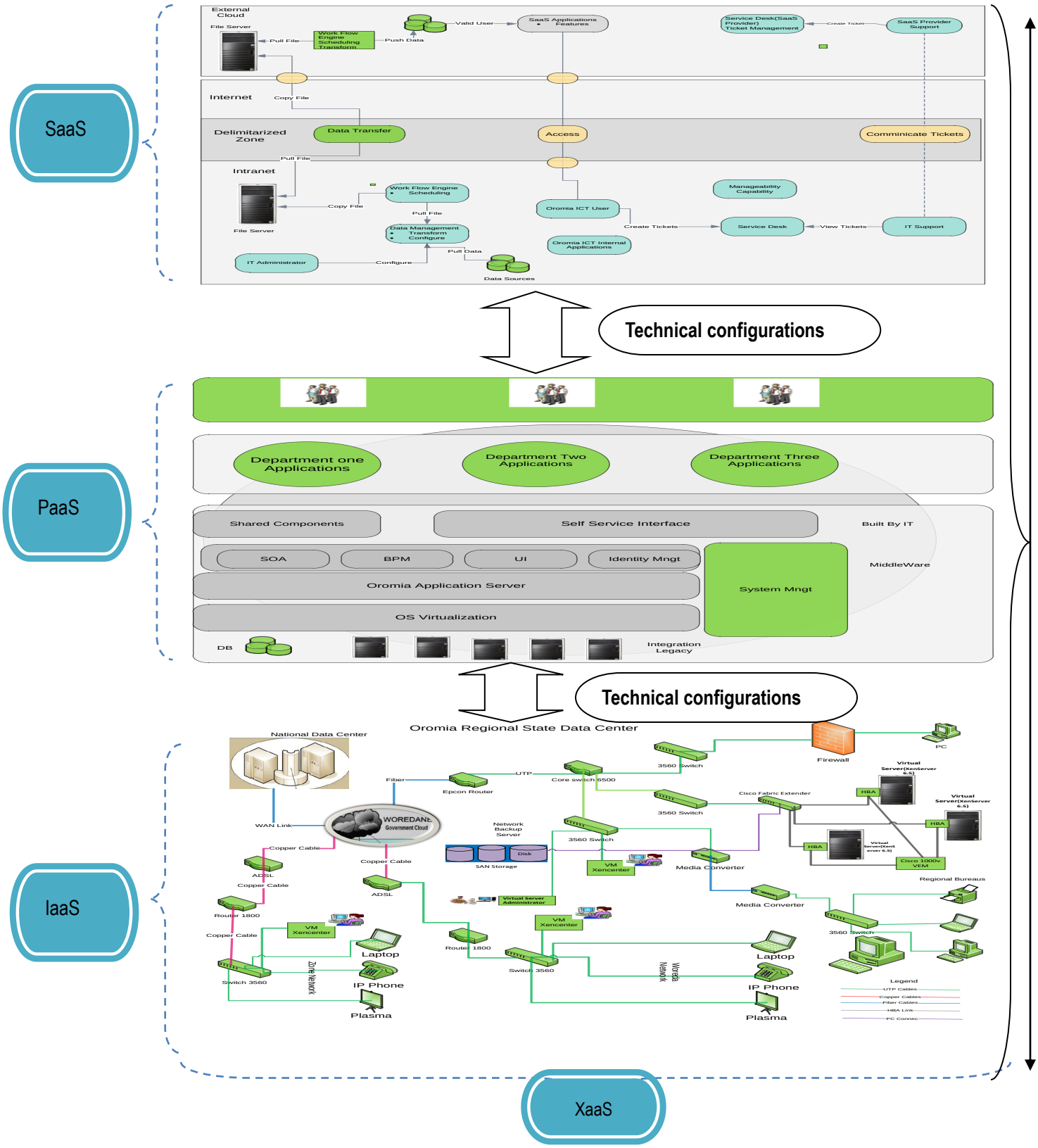


Figure 4.12 Adopted XaaS Architectures

XaaS is described as over all three components of cloud architectures. Basically at the ground level Cisco infrastructure as a Service is adopted. The infrastructure contains data center components including computing power and memory virtualizations. On the top of IaaS of Cisco cloud architectures we put Oracle PaaS architectures which is compatible with tools used in oromia regional state datacenter. Applications which are used by the datacenters is also adopted from Intel cloud providers.

4.10 Testing the Adopted Cisco XaaS Cloud Architecture in a LAN Environment

The testing is done in Oromia Regional Data Center, in a LAN environment. XenServer 6.5 is installed and configured on one server with 4 physical hard disks, each of size 500GB.The server computing power, CPU is core i3 which supports VT (Virtualization Technology).

To adopt Cisco cloud XaaS architecture, the research needs virtualization software, which manages the hardware resources of a server. In these sections, We try to demonstrate the base of cloud computing which is IaaS. After IaaS simulations test the rest of cloud computing layers like SaaS and PaaS are simple to virtualize. The software used to test the architecture that is going to be adopted is an open-source product called XenServer 6.5, which can support on-demand virtual machines provisioning, pre- configured and manage groups of interconnected virtual machines.

XenServer 6.5 host is installed on a physical machine, server. The purpose of installing XenServer 6.5 is to make the physical server to share resources such as storage, memory, CPU, NIC etc for different client machines connected to it with a LAN. The client machines can be any desktop computers or Lap top computers running their own OS and applications. A client application, XenCenter, will be installed on client computers and they share resources of the physical server through virtual machines created by XenServer 6.5 on the physical server. The system requirements for installing and configuring the XenServer 6.5 is ,it requires a machine that can be a server, the machine should support Virtualization Technology which can be enable in BIOS set up. It can be installed on two or more servers of the same hardware specifications to create storage pools. The system requirements and installation steps explained in Appendix C.

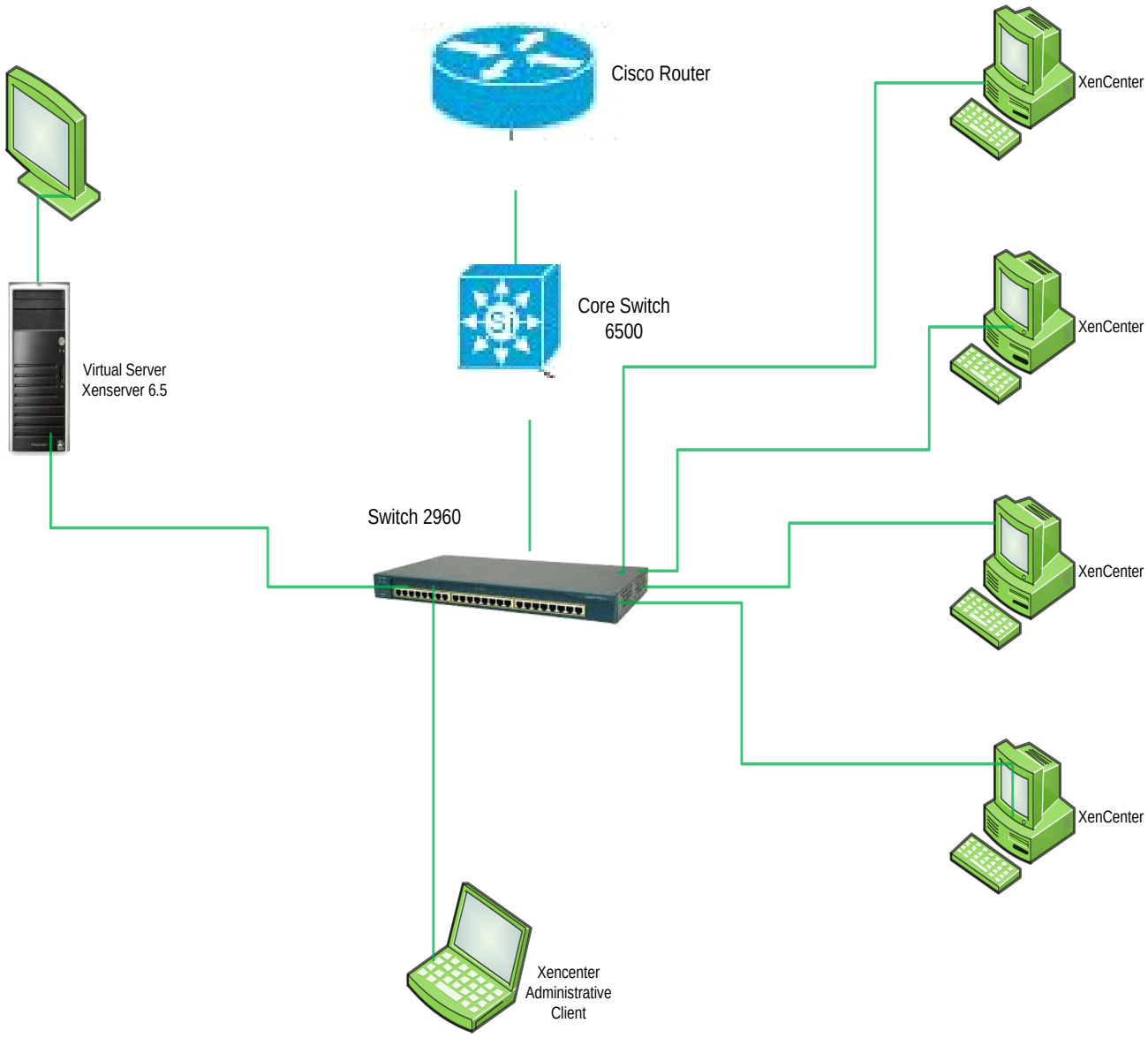


Figure.4.13: Test Cisco Iaas of XaaS with LAN enviroment

4.10.1 Description of the Testing Equipments

- One router, one core switch and one layer 2 switch are used in a LAN. All of these network equipments are already within the data center. The purpose of the router is assign the ip addresses automatically using DHCP.

- There are four desktop computers used to share resources of the server. XenCenter client application of XenServer is installed on each of these desktop computers. These desktop computers connect to the physical server by running the XenCenter and entering the ip address of the physical server.

- One desktop/laptop computer is also installed a XenCenter to manage the resources of the physical server. Personnel that have a super user right on XenServer 6.5 can only manage resources of the physical server.

4.10.2 Xencenter and Xenserver working environment

Figure 4.14: Citrix XenCenter Window

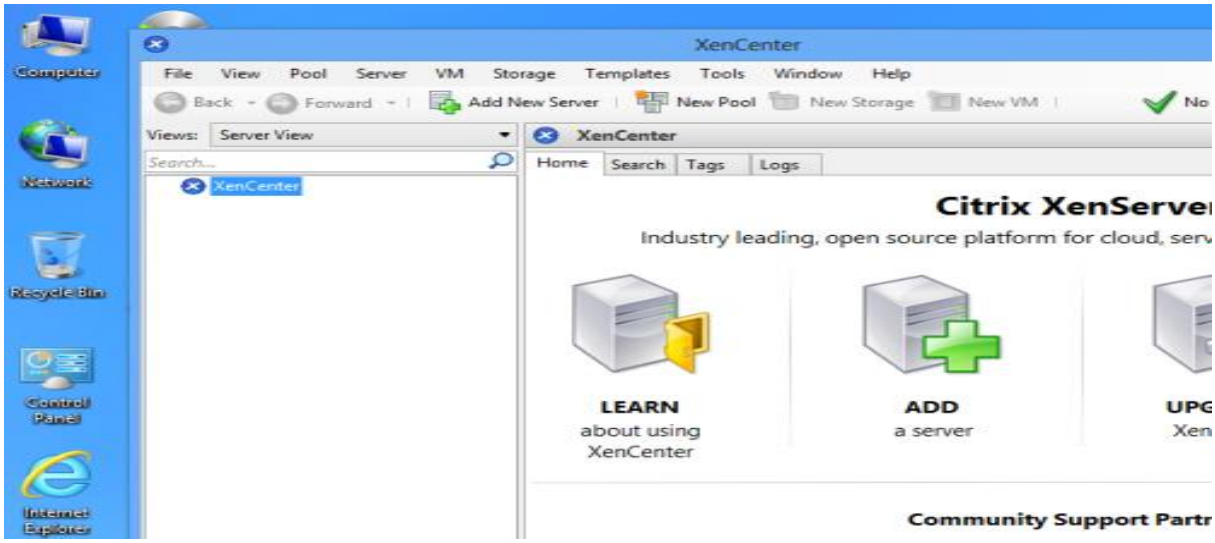


Figure 4.15: Citrix XenCenter Window

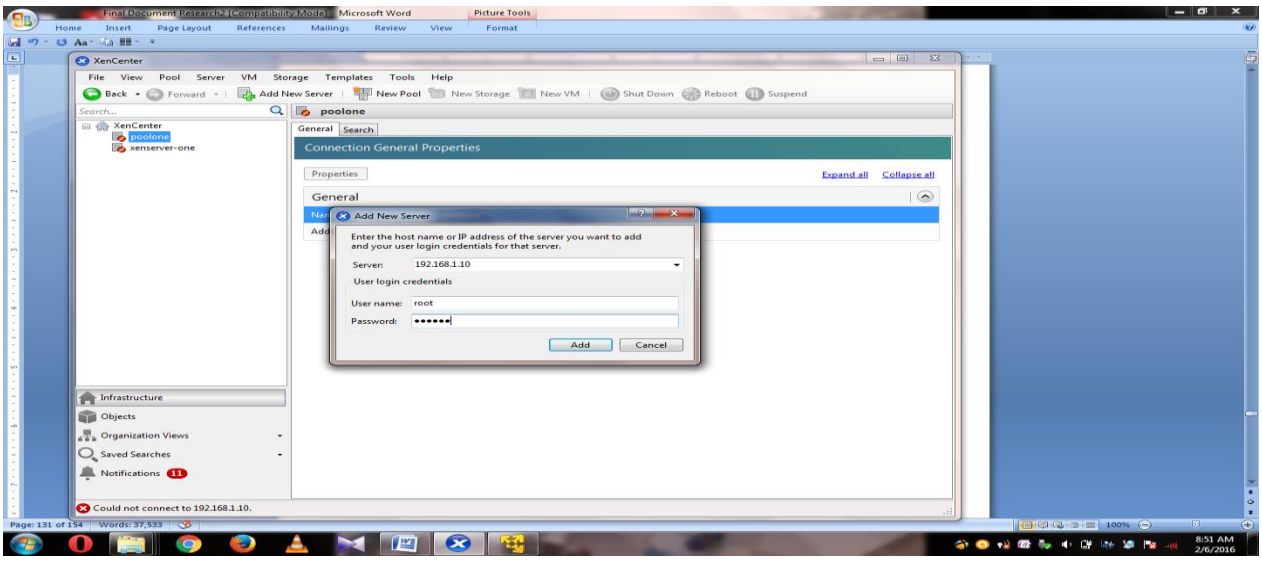


Figure 4.16: XenCenter Client Connecting to XenServer Host

The client machines installed with XenCenter are connected to XenServer host. The XenServer host automatically assigns the virtual machines to the clients. In this case the virtual machines assign resources of a physical server both dynamically and the administrator can assign resources manually during the configurations.

4.10.3 XenServer 6.5 Overview

Citrix XenServer® is the complete server virtualization platform from Citrix®. The XenServer package contains all you need to create and manage a deployment of virtual x86 computers running on Xen®, the open-source virtual zing hypervisor with near-native performance. XenServer is optimized for both Windows and Linux virtual servers. [50]

XenServer runs directly on server hardware without requiring an underlying operating system, which results in an efficient and scalable system. XenServer works by abstracting elements from the physical machine (such as hard drives, resources and ports) and allocating them to the virtual machines running on it. A virtual machine (VM) is a computer composed entirely of software that can run its own operating system and applications as if it were a physical computer. A VM behaves exactly like a physical computer and contains its own virtual (software-based) CPU, RAM, hard disk and network interface card (NIC). XenServer lets you create VMs, take VM disk snapshots and manage [50]

A value leader in the virtualization space, XenServer is an open source platform for cloud, server and desktop virtualization infrastructures. Organizations of any size can install XenServer in less than 10 minutes to virtualizes the most demanding workloads and automate management processes, thereby increasing IT flexibility and agility and lowering TCO. With a rich set of management and automation capabilities, a simple and affordable pricing model and optimizations for virtual desktops and cloud computing, XenServer is designed to optimize datacenters and clouds today and in the future. [50]

Key XenServer benefits are Cloud-proven virtualization that is used by the world's largest clouds, directly integrates with Citrix CloudPlatform and Apache™ CloudStack™ and is built on an open and resilient cloud architecture, Open source, community-driven virtualization from a strong community of users, ecosystem partners and industry contributors that accelerates innovation, feature richness and third-party integration and Value without compromise from a cost-effective and enterprise-ready cloud-proven platform that is trusted to power the largest clouds and run mission-critical applications and large-scale desktop virtualization deployments and Virtualize any infrastructure including clouds, servers and desktops, with a proven, high-performance platform [50]

Open source solutions are already driving innovation and capturing the cloud market, rapidly outpacing proprietary software in cloud infrastructures. Underpinning the evolution of XenServer for cloud enablement was the move to make it fully open source. An open source XenServer aligns with the dominant cloud orchestration platforms of Citrix CloudPlatform, Apache Cloud Stack and Open Stack and meets the expectations of cloud builders for source code availability, open APIs and ecosystem contribution and integration.[50]

4.10.3.1 How XenServer 6.5 is used

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

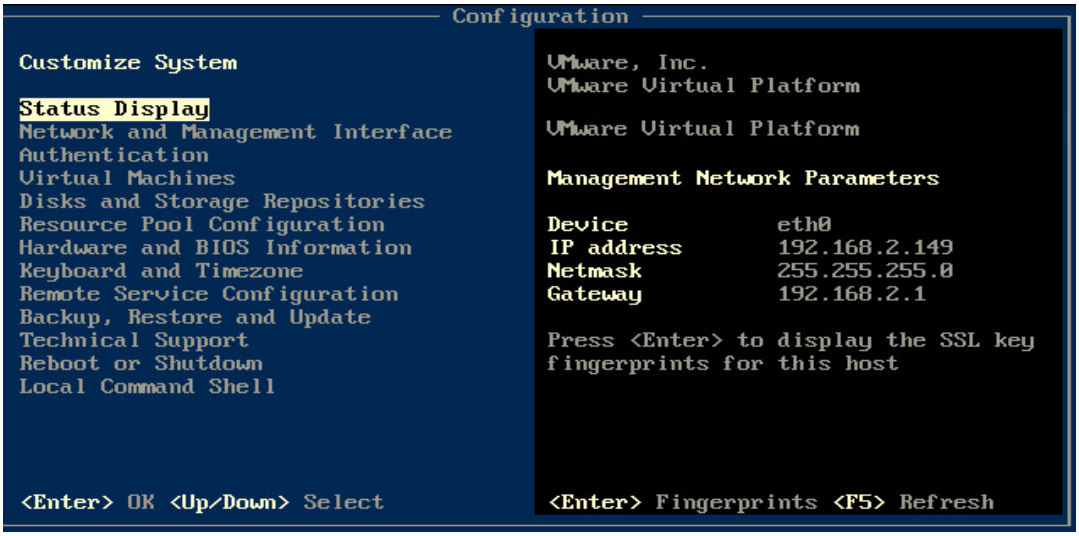


Figure. 4.17 :XenServer 6.5 Host Main Screen

4.10.3.2 Designing and Provisioning Infrastructure Services

The most powerful attribute of XenServer 6.5, is the speed and simplicity with which pools of infrastructure resources can be fixed, flexibly configured, and reconfigured to match the infrastructure requirements of nearly any application. We can deploy a single XenServer 6.5 environment in place of multiple different server configurations to satisfy varied application requirements for CPU, memory, network, and storage and quickly build our private cloud. Physical Server resources are then available on demand as infrastructure services for IT users to request using a service catalog. Physical Server resources are then available on demand as infrastructure services for IT users to request using a service catalog. Creating and Managing Resource Pools

An administrator can use the management console, XenCenter, to define pools of servers, network, and storage resources to support infrastructure services. Through the console, the administrator can also define virtual machine images and software deployment jobs, register user accounts, and assign resource pools to users.

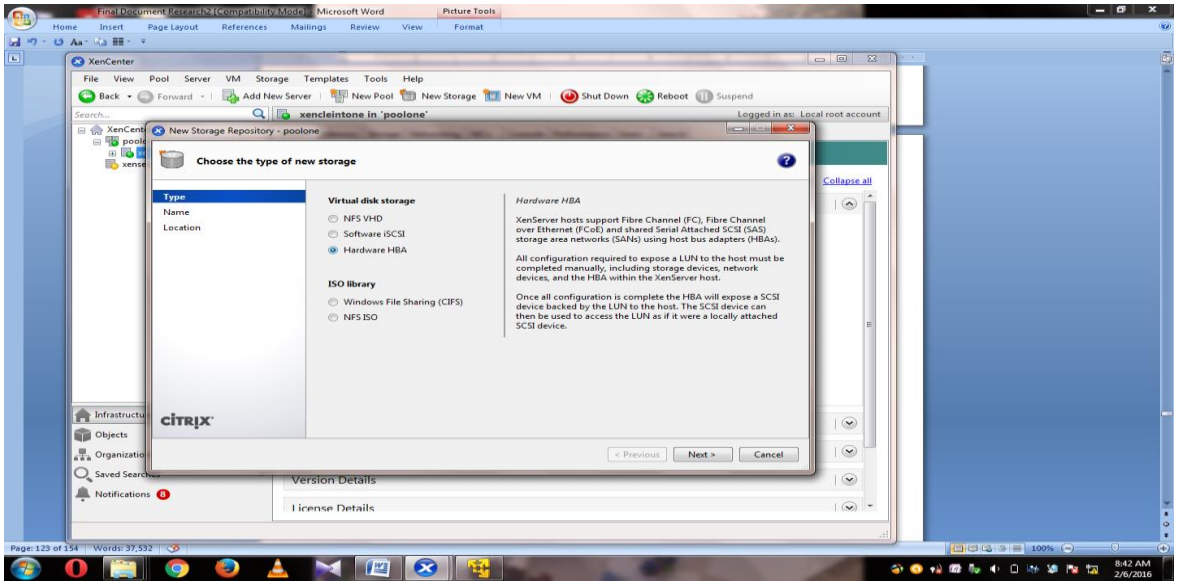


Figure. 4.18:Configuration of Local Storage for Virtual Server

Storage pool entries describe the storage requirements for the infrastructure services. The XenServer 6.5 administrator can create a storage pool entry to define the storage needs of a physical or virtual server such as a boot disk of a specific size, a shared data disk, and etc.

A storage administrator can create a storage catalog representing the available storage assets. These assets can include existing storage volumes that have been pre-provisioned by the storage administrator as well as specifications for volumes that can be created on demand.

Storage templates encapsulate policies specifying RAID level, capacity constraints, etc associated with the storage volumes. XenServer 6.5 can also auto-generate storage pool entries based on the logical disk specifications in the

service templates. In this case, XenServer 6.5 automatically matches the best candidate from the storage catalog to the request.

4.10.3.3 Storage Technologies

Key to the flexibility of the XenServer 6.5 solution is having the OS image and data reside on shared storage. Virtual machines can then migrate from one physical server to another and retain their personality, and continue to provide application support after reboot. For physical servers, XenServer 6.5 supports Fibre Channel storage and it can connect to our existing SAN. Through XenCenter, we can create virtual machines in a number of ways, according to our deployment needs. Whether we need to deploy individual VMs with distinct configurations and features or groups of multiple, similar VMs. After we connect XenCenter to the XenServer 6.5 host, storage is automatically configured on the local disk of the host. It is also possible to convert existing VM into a VM template. A VM template preserves our customizations so that we can always use it to create new VMs to the same specifications.

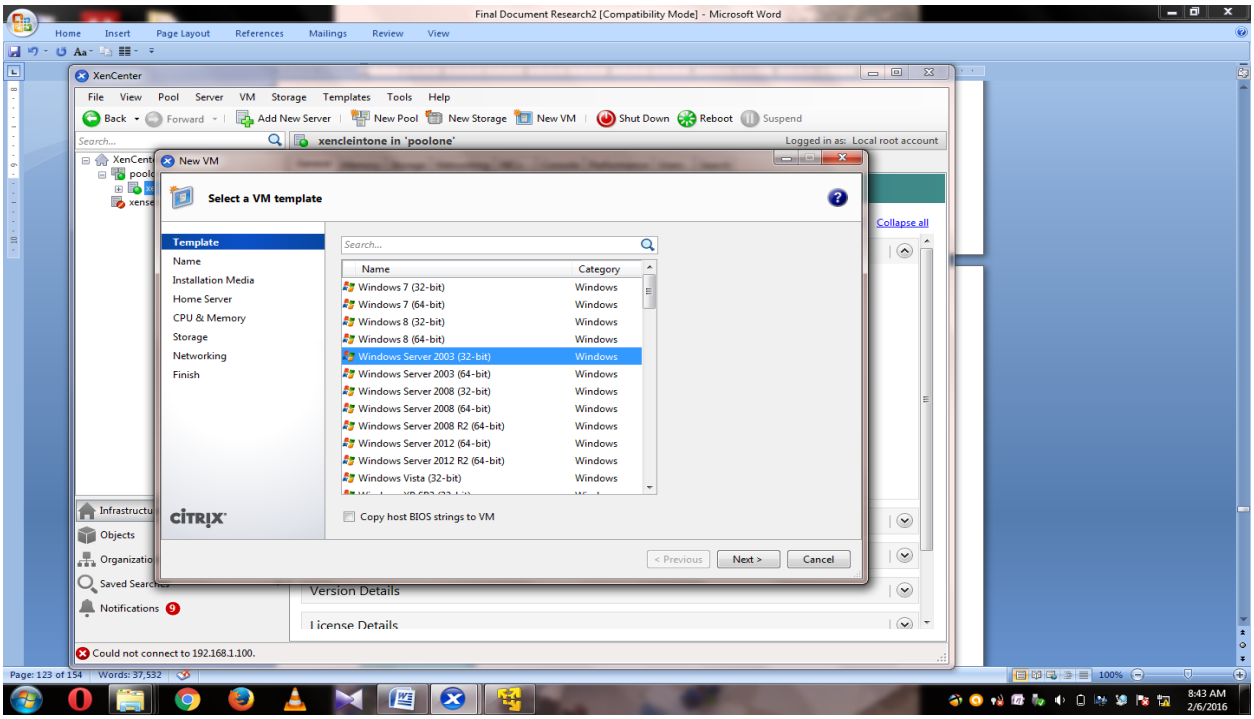


Figure.4.19: Creating Virtual Machine Templates

CHAPTER FIVE

5. Conclusion and Future Works

5.1 Conclusion and Findings

In this research, the critical role of ICT in e-governance, the status of ICT usage in Ethiopian public sectors, limitations of the current ICT service delivery from Regional data centers, the platform software's, the application software available and identification of better ICT service delivery technologies has been studied. ICT policies and e-government implementation strategy documents reviewed. It is concluded from Ethiopian ICT policy that Regional governments can optimize and upgrade their own data centers services at their own cost and hosting applications and how to use platform applications.

After identifying the requirements and limitations, the research showed that Cloud Computing can overcome most of these limitations and fill the gap of storage requirements to improve e-government service delivery. Thus, the idea of harnessing the Cloud Computing service in government data centers by utilizing Infrastructure as a Service (IaaS) to overcome the resource limitations particularly storage, computing power etc to enhance the e-government services by adding consolidation and virtualization tools seems feasible with XaaS in consideration. The primary focus of this research is to adopt Cloud XaaS architecture that can be used by oromia Regional data centers and then implemented as whole country datacenters. Regional Data Centers and other components of cloud like PaaS and SaaS implemented on this architectures, which would enable government services delivery much more efficient and effective than the current system.

From the different Cloud XaaS architectures, Cisco cloud IaaS architecture is chosen and adopted in Oromia Regional data center for Infrastructure Provisioning. Cisco cloud IaaS architecture is chosen based on factors and parameters that are more significant to consider in adoption of cloud service architecture mostly by cost parameters. The literature review in section 2 shows that the most significant factors to be considered to adopt cloud IaaS architecture are ***cost, bandwidth, performance, scalability, management, Integration, Standardization, Ease Of Use, Computability with Data Center equipments and security***. An open source virtualization tools, XenServer 6.5 and XenCenter has been used for the implementation and testing of the adopted Cloud XaaS architecture in small scale, LAN environment.

PaaS is also adopted for Oromia Regional State Data Centers. Based on the parameters ***cost, bandwidth, performance, scalability, management, Integration, Standardization, Ease Of Use, Computability with***

Existing Software Development procedures and security. PaaS of Intel Vender is adopted for the implementations of XaaS in Oromia Regional Data centers.

SaaS of Oracle Venders is also adopted in this research to make application usage in the Region more effective according to parameters ***cost, bandwidth, performance, scalability, management, Integration, Standardization, Ease Of Use, Computability with Existing application Software Usage and security***.

Questionnaire and interview are some of the methods used to conduct this research. The respondents were Regional IT heads, Regional data center administrators, Regional IT professionals and Ethio-Telecom broadband internet IT professionals.

Oromia ICT Development Agency director, Ato Mekonnen Beyene interviewed and told to the researcher after BPR study of the Region in 2000 E.C, business processes of 22 Regional bureaus have been automated by two software consultants and deployed in Oromia Regional data center. There is also software developed by Universities and Agency experts according to the Directors. All software's cost is also about 33,605,000.00 to develop the directors told the researcher.

However, the Director told the researcher that storage is a big issue in Oromia data center to deploy all these application as the need arises. He added, with the current 8 severs we cannot afford the storage requirement of the Region. It requires purchasing of servers for each Regional bureaus and allocating more bandwidth for each of the bureaus, which again incur capital expenditure.

But if Oromia Regional data center implemented the adopted Cisco cloud XaaS architecture, instead of purchasing more servers in the data centers few servers can serve the storage requirements of the bureaus who have automated their business process. The Agency director and two data center administrators validated the architecture from the following point of view.

- Cost reduction
- Scalability
- Ease of use
- Performance

Installing XenServer 6.5 host on one physical server can abstract the resources of the server by running 500 virtual machines which justifies that 500 users/client can connect to the server at the same time. In pool of servers, which is more than two servers, Xenxerver 6.5 has a feature of NIC bonding and if one physical server fails there will be live migration among virtual machines to the normal server. This reduces cost of purchasing additional servers.

Incase new server is added to the data center, there will be no scalability problem of the architecture because an administrator can easily configure the server with already existing pool of servers using XenServer 6.5 More clients

can be added to access resources of server pools since XenServer 6.5 has built-in active directory users and computers configuration features.

On the other hand if Oromia Regional State decanters can adopt Oracle PaaS architecture most of the problem of software development can be solved. Specially, cost of the software development which is covered by the agency about 33,605,000.00 can minimized and invested on another project of the Region. Maintenance of these applications is also major issues, which the agency cannot handle. So that, if PaaS is adopted and implemented these problems can be solved. SaaS is also one of the adopted and implemented in Oromia Regional sate datacenters. Intel SaaS cloud architectures is adopted based on the parameters set. SaaS, PaaS and IaaS now can be combined and implemented as XaaS for the research conducted in Oromia Regional State Datacenters. We conclude that these three models can be combined and from different vendors can form one architecture.

Table 5.1: Oromia RDC Equipments Cost Analysis (**Source**: Oromia ICT Development Agency)

Before Adoption of Cisco cloud IaaS architecture			
Data Center Equipments	**Quantity**	**Unit Cost (ETB)**	**Total Cost (ETB)**
Data Centers Equipments	16	8,096,000.000	8,096,000.000
After Adoption of Cisco cloud IaaS architecture			
Data Center Equipments	3	200,000.00	600,000.00
Additional Equipments to be purchased			
HBA adapter	3	22,000.00	66,000.00
Cisco Nexus 1000v VEM	2	40,000.00	80,000.00
Cisco Nexus 2100, Fabric Extender	2	30,000.00	60,000.00
		Total	**806,000.00**
		Total benefits	**8,096,000.00-1406000= 6,690,000**
Before Adoption of Intel cloud SaaS architecture			
Application Cost	13	NA	146,355.00
After Adoption of Intel cloud SaaS architecture			

Application Cost	1	Each applications are from the Internet	Estimated about 1,000,000.00
Before Adoption of Oracle cloud PaaS architecture			
Tools Cost	1	NA	33,605,000.00
After Adoption of Oracle cloud PaaS architecture			
Tools Cost	1	Each tools are from the Internet	Estimated about 10,000,000.00
Over All XaaS Before Adoption			41,847,355.00
Over All XaaS After Adoption			**41,847,355.00-10,000,000-1,000,000-806,000.00=30,041,355.00**

5.2 Conclusion

It can be concluded that cost of the adopted XaaS is about 30,041,355.00 which is decreased by one third of before Adoption. We analyzed cost effectively since the first criteria, which we can simply get and benefitted, as is cost. This research is also discussed about not only cost; it is also about many parameters like bandwidth, simplicity, and many another criteria's. Basically we try to see architectures that is compatible with the existing data centers Infrastructures and Systems available.

This research therefore confirmed that cloud XaaS architecture adoption is an almost inevitable part of the e-government service landscape as storage requirements of government sectors are increasing from time to time and virtualization in cloud computing offers a feasible solution for upgrading their current ICT infrastructure, be it application or hardware solutions.

In general in this research we assessed and analyzed not only cost but also many parameters have been discussed to adopt XaaS cloud architectures. In addition to this the following task has been performed.

- Existing data center architectures assessed and compared with IaaS cloud architectures
- Components of XaaS such as IaaS, PaaS and SaaS have assessed which is a ground for adoption.
- Policies to adopt cloud computing in Ethiopia is assessed and used in the adoption of cloud computing architectures.

5.3 Future Works

The adopted cloud XaaS architecture is a road map to adopt and implement other cloud computing services. The research possibilities regarding Cloud Computing for e-government services are enormous since the technology is relatively new. Research on data center services has much to be examined further.

The current study is also needs strengthen some of its limitations. The parameter which is used to adopt the new framework of XaaS is not tested in details. SaaS and PaaS parameters need further analysis and interpretations needs to be undertaken.

Further work which is not included in these research in the have to done by other scholars .Here are lists of some of the future work to be done to scale-up the adopted cloud XaaS architecture:

- In addition to this research the following three future works that We recommends
    - Adopting the security of XaaS in case of Oromia Regional State datacenter.
    - Adopting bandwidth conception of XaaS cloud services in case of Oromia Regional State data centers
    - Adopting XaaS in public cloud services in case of Ethiopian e.governance services

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Appendices

Appendix A: Questionnaires

Hint:-IaaS=infrastructure as a service

Paas=Plaform as a service

SaaS = software as a service

XaaS= every thing as a service

Student Name:- Kedir Elka

Program:- MSC In Information Science

University:- Adama Sceince and Technology **University**

Department:- Computing

Msc in Information Science Thesis Questioner Revised

This questioner is filed by NDC and OICTDA			
1.	Date of interview		
2.	Name of respondent		
3.	Position within the Organization		
4.	Email address		
Organizational History			
1.	Name of Organizations		
2.	Organization main objectives/functions	a. ❑Service provider(Internet) b. ❑ IT infrastructure service (software and network, datacenter…) c. ❑Customer service(internet) d. ❑Cloud provider e. Other _____	
Cloud Computing Technology			
1.	Do you have an overview of cloud computing?	a. ☐Yes b. ☐No	
2.	If your answer to question No 1 above is no, what is the reason?	e. ☐ Lack of Skill f. ❑ lack of interest g. ☐Organizational policy toward cloud h. ☐ other problem	
3.	Do you think that services offered through the cloud necessarily more **agile than traditional solutions**?	f. ☐Strongly agree g. ☐Somehow agree h. ☐Not Sure i. ☐Somehow disagree j. ☐Strongly disagree	
4.	**Does Usability** of the cloud based services affect your organizational working process if applicable?	f. ☐ Strongly agree g. ☐Somehow agree i. ☐Not Sure j. ☐ Somehow disagree k. ☐Strongly disagree	
5.	What are the **barriers** to effectively shifting the business to cloud services?*(select all that apply)*	h. ☐Lack of Technology i. ☐Lack of Providers j. ☐ Lack of Technical support k. ☐Lack utility services l. ☐ Lack of policy m. ☐Lack of knowledge n. Other_____	
6.	Do you think that using cloud computing services a	a. ☐Yes b. ☐No	

	sustainable business?		
7.	If **NO**, what are factors that make it unsustainable*(select all that apply)*	o. ☐ Limitation of knowledge p. ☐Operational costs q. ☐Legal concerns r. Others_____	
8.	Do you think that lack of technical skills (human capacity) slow down the usage of Cloud Computing in your organizations?	i. ☐ Strongly agree j. ☐Somehow agree k. ☐Not Sure l. ☐Somehow disagree m. ☐Strongly disagree	
9.	Name skills that are critically lacking*(select all that apply)*	h. ☐ General overview i. ☐technical knowledge j. ☐Security k. ☐Architecture/Design l. ☐Virtualization m. ☐All the above n. Other_____ ___	
10.	If your organization willing to use or adopt cloud computing which deployment models want to use?	d. ☐Public Cloud e. ☐Private Cloud f. ☐Hybrid Cloud	
11.	Do you have any plan to use cloud-computing services?	a. ☐Yes b. ☐No	
12.	If your answer to question no 11 above is yes which service model you want to use?	a. ☐SaaS b. ☐PaaS C. ☐IaaS D. ☐XaaS	
13.	If you answer to question no 12 is SaaS, what are the services you want to deploy on cloud?(pls tick all that apply)	f. ☐MIS g. ☐CRM h. ☐ERP i. ☐Mail Server j. ☐Portal n. ☐Office application (office, antivirus, accounting software…) o. ☐Bureaus specific applications p. Other_____	
14.	If you answer to question no 12 is PaaS, what are the services you want to deploy or access on/from cloud?(pls tick all that apply)	i. ☐Java j. ☐Oracle database k. ☐C# l. ☐SQL server m. ☐PHP n. ☐Windows OS o. ☐Linux OS p. other_____	
15.	If you answer to question no 12 is IaaS, what are the services you want to deploy or access on/from cloud?(pls tick all that apply)	d. ❑computing power e. ❑Networking f. ❑Storage	
16	**Promoting** cloud computing government offices significantly determines growth of service delivery and bringing the work efficiency and effectiveness.	f. ☐ Strongly agree g. ☐ Somehow agree h. ☐Not Sure i. ☐Somehow disagree j. ☐Strongly disagree	
17.	Is your organization willing to use(adopt)cloud computing to give on line IT services? (tick all that apply)	h. ❑We don't have money to adopt i. ❑We are giving cloud computing services already j. ❑ We expect to adopt within the short time k. ❑We expect to adopt within the long time l. ❑ There is insufficient knowledge to adopt Cloud computing	

		m. ❑No intention to adopt Cloud computing n. Others, Specify_____	
Cloud computing Policy Frameworks			
1.	Is there any policy that support adoption and use of cloud computing?	c. ☐Yes d. ☐No	
2.	If your answer to question No 1 is yes, Does the existing **policy framework give** you **flexibility** to exploit cloud computing as you wish?	f. ☐Strongly agree g. ☐Somehow agree h. ☐ Not Sure i. ☐somehow disagree j. ☐Strongly disagree	
Institutional authority to the cloud			
1.	What support the government providing in relation to Cloud Computing implementation?	a. ---------- b. ----------	
2.	What kind of support do you think the government should provide?	a. _____ b. _____	

Traditional ICT Services			
1.	Which traditional ICT Services your organization offering? Pls tick all that apply)	d. ☐Data Center e. ☐Mail f. ☐collaboration s. ☐Social Networking t. ☐Application hosting u. ☐ Web Hosting	v. ☐Video Conferencing w. ☐Voice IP x. ☐Directory Service y. ☐Portals z. ☐Instant Messaging aa. ☐Document Sharing bb. Other _____
2.	Which one of the following applications developed and used by your organizations? (Pls tick all that apply)	a. ☐Human resource management system b. ☐Court management system c. ☐Attendance management system d. ☐Crime management systems e. ☐ Billing management systems f. ☐Payment management systems g. ☐District Management systems h. Other pls specify_____	
3.	If your organizations have an application, where do you deploy?	g. ☐ OICTDA server h. ☐ Dedicated server i. ☐Tele server j. ☐NDC server	k. ❑On cloud l. Other _____ _____
4.	From where your organization can get access of applications software?	a. ☐ From market b. ☐from government	

		c. ☐In house development d. other_____	
5.	From where your organization can get access of platform software?	a. ☐ From market b. ☐from government c. ☐In house development	d. ☐other_____ _____
6.	Do your organizations have experience of buying licensed software?	a. ☐Yes b. ☐No	
7.	If your answers to questions No 6 is yes, what are the software's?	a. ☐C# b. ☐Oracle c. ☐SQL server	d. ☐Antivirus e. ☐Server 2003, 2008 f. ☐Office g. Other----------
8.	If your organization bought application or operating system, software how much it costs per applications?	a. ☐ <2000 b. ☐2000-10,000 c. ☐10,000-50,000	d. ☐50,000-100,000 e. ❑>100,000
9.	Which of the following equipments available in your organization datacenter? Choose all that apply)	a. ☐Web Servers b. ☐Core Routers c. ☐Core Switches d. ❑Fiber Channel e. ☐SAN Storage	f. ☐Firewalls g. ☐Ethernet Fabric h. ☐Database Servers i. Others specify_____
10.	Is there any virtualization technology available in your data center?	a. ☐Yes b. ☐No	
11.	Do your organizations have backup media and policy?	a. ☐Yes b. ☐No	
Woredanet Questions			
1.	Do you think that the existing Woredanet bandwidth enough to accommodate all services available?	a. ❑YES b. ❑ NO	
2.	If answer to question 1 is No, what do you recommend?	a. ❑Bandwidth upgrade b. ❑Using the existing bandwidth c. ❑ The plan takes a long time	
3.	How much bandwidth do you recommend for all services?	a. ❑2mbps – 3mbps b. ❑3mbps – 4mbps c. ❑4mbps – 8mbp	d. ❑8mbps – 15mbps e. ❑15mbps 20mbps f. ❑20mbps -40mbps g. Other_____ ___

Appendix B: Interview Questions

Interview Questions

Interview Questions for Data Center Administrators

1. What types of applications are running within data centers?
2. Is the existing bandwidth sufficient to run these applications?
3. What fraction of bandwidth is contributed by each application?
4. How do you pay for these services for service provider?
5. How do you manage Data Center resources?
6. What are the primary equipments in Data Center?
7. How many servers are there in Data Center?
8. Who are your customers?
9. Have faced problems while giving Data Center services?
10. What type of problems?
11. How do you solve problems of server down times?
12. Do you have SLA with the service provider?
13. What are your first impressions of Cloud Computing?
14. If many organization are looking for storage in the Data Center, what are your biggest concerns?
15. How do you secure Data Center resources?

Interview Questions for EthioTelecom Broadband Internet IT Experts

1. You company is an ISP, do you have a plan to be CSP?
2. Is the existing backbone infrastructure suffices to provide cloud services?
3. Are your experts trained on Virtualization and cloud service provision?

Appendix C: Installing Xenserver 6.5 and Xencenter 6.5

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

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

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

Install the XenServer 6.5

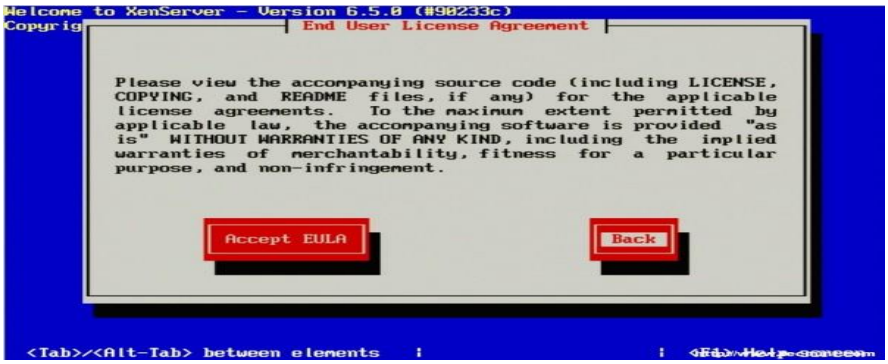
System requirements is a Physical Server with

- **CPUs**: One or more 64-bit x86 CPU(s), 1.5 GHz minimum, 2 GHz or faster multicore CPU recommended
- **RAM**: 2 GB minimum, 4 GB or more recommended
- **Disk Space**: Locally attached storage (PATA, SATA, SCSI) with 16 GB of disk space minimum, 60 GB of disk space recommended, or SAN
- **Network**: 100 Mb/s or faster NIC. One or more gigabit NIC(s) is recommended
- XenServer installation CD/DVD.

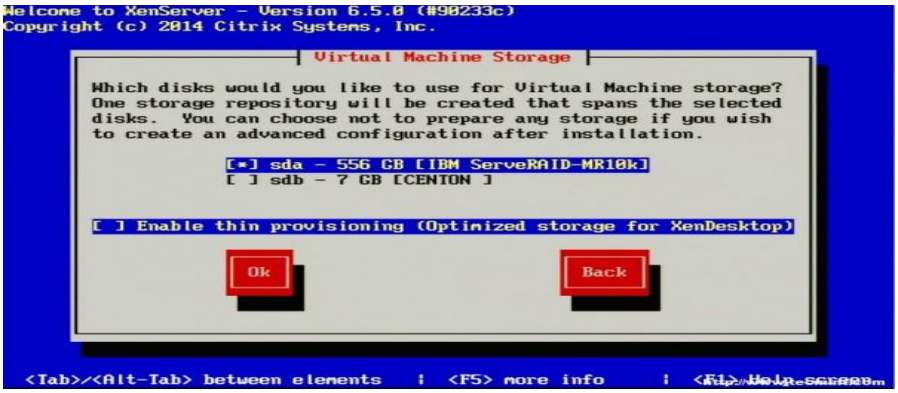
Steps:

1. Insert the main installation CD into the DVD drive of the host computer.
2. Restart the host computer.
3. Boot from the DVD drive (if necessary, see your hardware vendor documentation for information on changing the boot order).
4. Following the initial boot messages and the Welcome to XenServer screen, select your keyboard layout for the installation.

5. When the Welcome to XenServer Setup screen is displayed, select Ok.
6. Read and accept the XenServer End User License Agreement (EULA).



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

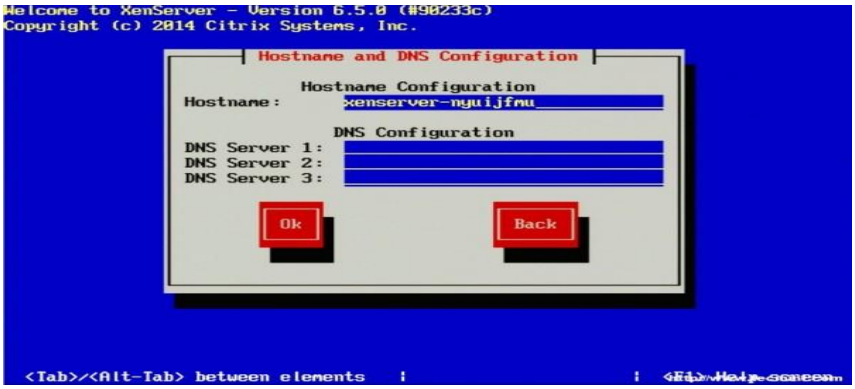


8. Select Local media as your installation source.
9. When prompted about if you would like to install any supplemental packs, choose No to continue.
10. Select Skip Verification, and then choose Ok.
11. Set and confirm a root password, which the XenCenter application will use to connect to the XenServer host.

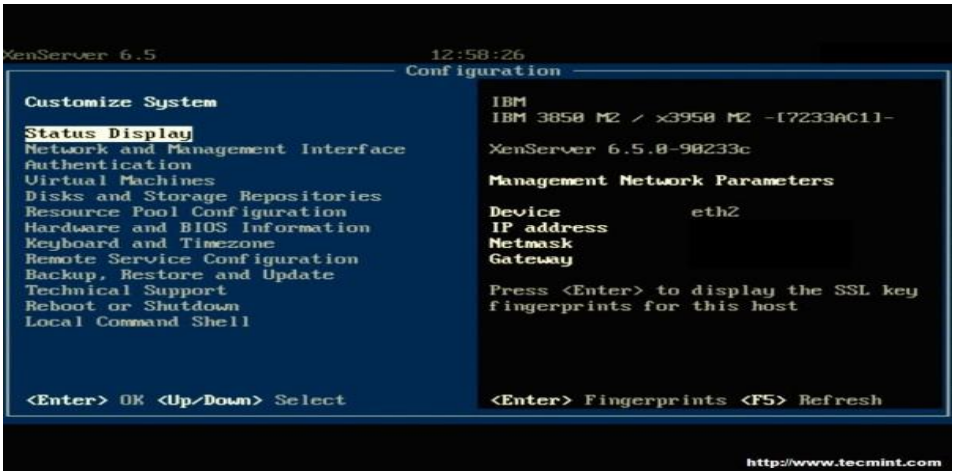
12. Set up the management interface that will be used to connect to XenCenter.If your computer has multiple network interface cards (NICs), select the NIC which you want to use for management traffic (typically the first NIC). A network port that is not tagged as a VLAN is required for the management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

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

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



15. Select your time zone — the geographical area and then city.
16. Specify how you would like the server to determine local time: using NTP or manual time entry. Choose Ok.
17. Select Install XenServer.
18. If you elected to set the date and time manually, you are prompted to do so.
19. From the Installation Complete screen, eject the installation CD from the drive, and then select Ok to reboot the server.



Installing XenCenter

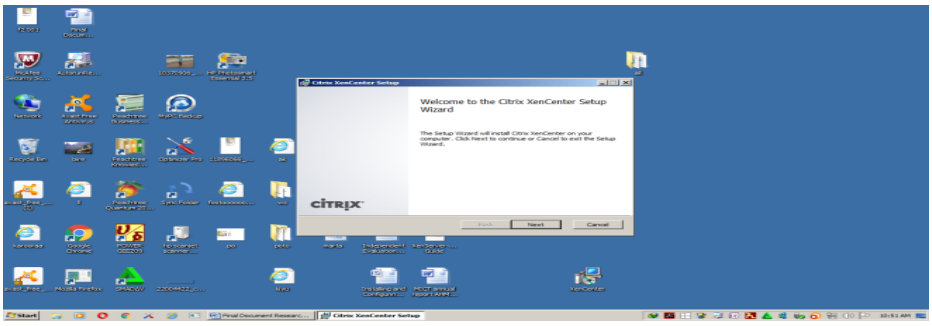
The system requirements for XenCenter are local desktop or laptop with

- **Operating System:** Windows 7, Windows XP, Windows Vista, Windows Server 2003, Windows Server 2008,Windows Server 2008 R2 (all editions and versions)
- **.NET Framework**: Version 3.5 or greater
- **CPU Speed**: 750 MHz minimum, 1 GHz or faster recommended
- **RAM**: 1 GB minimum, 2 GB or more recommended
- **Disk Space**: 100 MB minimum

- **Network**: 100Mb or faster NIC
- **Screen Resolution** :1024x768 pixels, minimum.

To install XenCenter;

1. Insert the main installation CD into the DVD drive of the computer which you want to run XenCenter.
2. Open the **client_install folder** on the CD. Double-click **XenCenter.msi** to begin the installation.



3. Follow the Setup wizard, which allows you to modify the default destination folder and then to install XenCenter.
4. In the **Server** field, enter the IP address of the host.Enter the root username and password that you set during XenServer installation.Choose **Add**.
5. Finally the following will be displayed

Indexes

List Of Basic Commands for Xenserver 6.5

xe help --all|more

Show a list of XenServer CLI commands

xsconsole

Runs up the XenServer text based console

xe-toolstack-restart

Restarts the XenServer management tools

ls –l

List files in a Directory

less /var/log/dmesg

Display Boot Messages from Linux

xe host-dmesg

Xen Hypervisor Boot messages

tail –f /var/log/xensource.log

Look at xapi messages as they happen

tail –f /var/log/xensource.log | grep xxx

Look at xapi messages only for vm uuid xxx

tail –f [log name] > [target filename]

Send output to a file for analysis later

cat /etc/xensource-inventory

Display XenSource Inventory info

xen-bugtool --yes

Build a status report when xapi is down

xe-backup-metadata -d –u [uuid of SR]

Back up Pool metadata for all VMs

tcpdump –i [inf] –vvv –w [filename]

Get a Packet trace from [inf]. E.g. Inf=eth0, xenbr0, vif2.0 etc.

top

List the top processes running in Dom0

xentop

List top Xen processes

mpstat 5

Processor stats in Dom0

vmstat 2

Virtual memory in Dom0

netstat –s

Networking statistics

iostat -d 2 6

Storage traffic stats

list_domains

Lists VMs that are running

fdisk –l

List the disk partitions

hdparm –t /dev/sda3

Device read times for sda3 (normally local SR)

pvs

Show local and remote LVHD SRs

ll /dev/disks/by-id

Look at disk partitions

lvs

List logical volumes (virtual disks)

vgs

List LVM volume groups

cd /var/run/sr-mount

Look at NFS SRs

df -h

Shows how much disk space you have left

dd if=/dev/sdb of=/dev/null iflag=direct bs=1M count=512

Read data performance from sdb.

dd if=/dev/zero of=/dev/sdb oflag=direct bs=1M count=4096

Write performance on sdb. * Don’t use on disks with

VMs on them!

ifconfig

Show info on NICs, virtual switches and vNICs

brctl show

Show info on virtual switches

ethtool eth0

Info for NIC eth0

mii-tool

Info on NIC bonding

iscsiadm -m discovery --type sendtargets --port 192.168.250.14

Discover iSCSI targets available to this server

iscsiadm –m session

Open iscsi sessions

history

Lists the history of commands you've used

!136

Executes command #136 in the history

history -w history-list.txt

Writes the history info to a text file