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A Hybrid Cloud Computing and Service Environment for Ethiopian Banks

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science in Information Science

BY: Kebede Solomon Belay

June, 2017

DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented as a partial degree requirement for a degree in any other university and all sources of materials used in the thesis have been duly acknowledged.

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KEBEDE SOLOMON BELAY

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

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June 2017

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List of Figures

Figure 2.1: Cloud Computing Definition

Figure 2.2 Private cloud computing

Figure 2.3 Public cloud computing

Figure 2.4 Hybrid cloud computing

Figure 2.5 Community cloud computing

Figure 2.6 Results for NIST Cloud Challenges Survey

Figure 2.7 Cloud Portability

Figure 3.1 Research methodology in this thesis

Figure 5.1 proposed cloud model

List of Acronyms

AAU -------Addis Ababa University

ATM-------Automated Teller Machine

AWS ------Amazon Web Service

CBE--------Commercial Bank of Ethiopia

CBS------ Core Banking Solution

CC --------- Cloud Computing

CRM ------Customer Relation Management

CSP -------Cloud Service Provider

DB ------- Database

EBs------ Ethiopian Banking Sector

ERP ------Enterprise Resource Planning

GUI ------Graphical User Interface

IaaS ------Infrastructure as a Service

IBM ------International Business Machine

ICT -------Information Communication Technology

IT ------- Information Technology

NBE----- National Bank of Ethiopia

OS -------Operating System

OSS -----Open Source Software

PaaS -----Platform as a Service

POS-------Point Of Sale

QoS ------Quality of Service

SaaS -----Software as a Service

SLA ------Service Level Agreement

SOA ------Service Oriented Architecture

VM -------Virtual Machine

VPN ------Virtual Private Network

Contents

Acknowledgment i
List of Figures ii
List of Acronyms ii
Abstract vii
Chapter 1 1
1. Introduction 1
1.1 Background 1
1.2 Statement of the problem 2
1.3 Research Questions 3
1.4 Objective of the study 3
1.4.1 General Objective 3
1.4.2 Specific Objectives 3
1.5 Significance of the study 4
1.6 Scope of the study 4
1.7 Organization of the Thesis 4
Chapter Two 6
Literature Review 6
2.1Cloud Computing 6
2.1.1 Definition 6
2.2 Cloud Computing Deployment Models 7
2.2.1 Private cloud 7
2.2.2 Public Cloud 9
2.2.3 Hybrid Cloud 10
2.2.4 Community Cloud 12
2.3 Cloud computing services 13
2.3.1 Infrastructure as a Service (IaaS) 13
2.3.2 Platform as a Service 14

2.3.3 Software as a Service (SaaS) 15
2.4 Characteristics of Cloud Computing 16
2.5 Cloud Computing Benefits for Banks 17
2.6 Information Technology and banks 18
2.6.1 The importance of IT in banking 18
2.6.2 Challenges of current IT systems on banks 19
2.7 The Future of Cloud Computing at Banks 20
2.8 Existing IT practice in Ethiopian banking sector 21
2.9 Key Concepts and challenges of the transition 21
2.9.1 Technological Challenges 22
2.9.2 Organizational Challenges 25
2.9.3 Social Challenges 27
2.9.4 Governmental Challenges 28
2.9.5 Security 29
CHAPTER 3 31
Research Methodology 31
3.1 Research Design 31
3.2 Interview Process 34
3.2.1 Interview Objective 34
3.2.2 Interview Preparation 34
3.2.3 Sampling Participants 35
3.3 Threats to Validity 36
3.3.1 Threats to validity for Interview study 36
Chapter Four 38
Findings and Discussion 38
4.1 Basic formation of cloud computing adoption 38
4.1.1 Risks and Advantages of Cloud computing 39
4.1.2 Capability of the Banks 41
4.1.3 Limitation of IT Investments and Norms 42
4.1.4 External Factors 42
4.2 Suggesting the cloud environment 46
CHAPTER 5 51
PROPOSED MODEL 51

5.1 Inputs for designing the new cloud model 51
5.2 Designing the model 52
5.3 Analysis of designed model 57
5.4 Suggestion given by Ethiopian Banks 58
CHAPTER 6 59
Conclusion and Recommendation 59
6.1 Conclusion 60
6.2 Answering the research questions 61
6.3. Recommendation 63
References 65
Appendix 75

Abstract

Information technology is the common element for all the industries this days. Consequently any important change in this area will have a direct or indirect impact on small and large scale organizations. One of the technologies that have an influence on IT is cloud computing. Due to the importance and sensitive nature of data/applications used by financial institutions, and other factors such as, competitions, changing customer, and line of business needs, Ethiopian banks face problems in providing necessary services to customers, allies, and employees, by using the ideal channel at any time. The main goal of this research is to examine how Cloud computing could change the way services are provided to customers, employees job satisfaction for Ethiopian banks. In order to do so, a proposed cloud model has been introduced based on existing cloud models and services in combination with the opinion of IT experts from selected Ethiopian banks.

Literature review and Interview were used as the research methodology for this thesis. Detailed study regarding cloud computing, services, models, and its security has been done. Moreover interview was selected for gathering opinions from the selected IT leaders and experts of the banks. The general architecture, its features that form cloud infrastructure, best practices in other countries, were also explored in this paper.

In this research I proposed Hybrid Cloud Computing model consisting Private Cloud and Community Cloud model. This proposed model would have the advantage of effective, efficient, reduced IT investment cost, reduce time to maintain system failures, and improve employee's satisfaction for delivering better banking services to customers.

Keywords: Cloud Computing, Cloud model, Ethiopian Banks,

Chapter 1

1. Introduction

1.1 Background

The evolution of high speed networks and computing power is making possible to process different banking services or applications in microseconds undreamed of in the past [1]. Cloud computing in this days become a common term in the computing world and it indicates the beginning of a new computing paradigm [2]. This paradigm is quickly developing and attracts a number of customers and vendors alike especially in developed countries. The quick development of cloud computing is being fuelled by the emerging computing technologies which allows for reasonably priced use of computing infrastructures and mass storage capabilities. It also removes the need for heavy upfront investment in Information Technology (IT) infrastructure. Cloud computing is a computing paradigm that involves outsourcing of computing resources with the capabilities of expendable resource scalability, on-demand provisioning with slight or no up-front IT infrastructure investment costs [3].

Cloud computing offers its advantages through three main types of service or delivery models namely infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS) and software-as-a-Service (SaaS). It delivers its service through four deployment models these are, public cloud, private cloud, community cloud and hybrid cloud [4].

Cloud computing is an internet-based computing, where users can share resources, information and software. The recent development of Cloud Computing offers an inspiration for organizations to outsource their Information and Communication Technology infrastructure (ICT). This work describes how the large scale organizations like Ethiopian Banks can use cloud computing effectively by suggesting them the services and cloud environments with respect to performance, security, cost, flexibility and functionality.

1.2 Statement of the problem

Ethiopian banks are currently using traditional client-server based architecture, where the same infrastructures, platforms and software are placed in their own data centers. This leads to several processors, servers, security and network communication to be maintained by their own employees, thus resulting in high cost of deployment and operation. In order to overcome these issues, I am going to suggest a suitable cloud environment with respect to cost, security, performance, flexibility and functionality. In this study the proposed hybrid cloud model for Ethiopian banks, which can also be used by other large scale organizations. With this new model, data and applications in Ethiopian banks can be managed and maintained securely with better performance and functionality.

Ethiopian banks are also handling several problems like troubleshooting software, extending the license of the product, hiring more employees to overcome the technical problems, etc. That is caused by the traditional client-server based services. To maintain and manage these services, Ethiopian banks needs to have more funding and increased man power. In order to overcome these issues I have done a literature study and conduct interview on different cloud environments (public, private and hybrid cloud) and cloud services (Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (PaaS)) and described different cloud service providers with respect to their properties. In this way, Ethiopian banks can consider one or more services to be outsourced from cloud service providers. The services could be maintained and managed by the cloud providers securely.

Therefore, the selected Hybrid cloud computing model for all banks in this study are designed to support a secure and cost effective electronic services sharing between customers, banks and cloud services providers, facilitating smooth collaboration and integration. To the best of my knowledge there is only one paper on cloud computing on banking that develop a framework to adopt cloud computing for Ethiopian banking sector so it has gap for not considering community cloud for Ethiopian banks.

1.3 Research Questions

1. Select which environment (public cloud, private cloud and hybrid cloud) would be suitable for Ethiopian Banks with respect to performance, security, cost, flexibility and functionality?

2. How the services Infrastructure-as-a-Service (IaaS), Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) could be used and how these services could be firmly integrated with the suggested cloud environment by Ethiopian Banks?

1.4 Objective of the study

1.4.1 General Objective

The main goal of this thesis is to study the existing IT infrastructure with its practice and suggest a suitable cloud environment, services and develop cloud based model and evaluate, by considering performance, security, cost, flexibility and functionality for Ethiopian banks.

1.4.2 Specific Objectives

- Review literature related to cloud computing and understand various cloud services, deployment models, and model development methods.
- Assess the current ICT infrastructure, effectiveness and efficiency of its usage in Ethiopian banks.
- Examine the necessity and major benefits of cloud computing for Ethiopian banks.
- Suggest a suitable cloud environment (Public cloud, Private cloud and Hybrid cloud).
- Propose a new cloud model to substitute the existing traditional client-server based model, after identifying the above cloud environments and services.
- Evaluate the proposed model based on performance, security, cost, flexibility and functionality.

1.5 Significance of the study

This Thesis could show the financial institution like Ethiopian banks to consider other ways of deploying IT infrastructures for an efficient and effective service delivery for their customers. The research would give some insights to the Ethiopian banks and other financial sectors on how to invest IT budgets and use it effectively on their institution. The Proposed Hybrid cloud computing model can be used as a baseline for the realization and practice of the cloud. In addition the study could be used as a baseline for further studies of this newly emerged IT utilization strategy to be considered in different governmental and non-governmental organizations in Ethiopia. The proposed Cloud Computing model could also be used as initiative for Ethiopian banking industries IT leaders on how this concept can be implemented at their companies.

1.6 Scope of the study

The main intension of the research is to examine Ethiopian banks service delivery model and its limitation and take to account cloud computing model as their IT infrastructure by proposing cloud computing model that can be used as their initiative for future use. This study does not consider to develop cloud computing service implementation prototype. It focus on exploring possible cloud service model that can be implemented in the future.

1.7 Organization of the Thesis

Chapter 2- Literature review that describes the theoretical background of CC, and the different kinds of cloud computing environments and services. I also describe the benefits and limitations of CC environments and services.

Chapter 3- Research methodology that is used in this thesis and the reason why those specific research methods are selected. It describes exploratory research approaches and primary data collection and analysis technique that has been used in this thesis. Validity and reliability requirements also identified.

Chapter 4- explains the results of interviews which I had conducted with the selected banks, which is followed by the analysis of the results and a suggestion of a suitable cloud environment.

Chapter 5- describes the specifications and analysis of the model designed in the suggested cloud environment. Additionally, technological requirement identification for Ethiopian banks also presented.

Chapter 6- presents the conclusion, results and future work of this research.

Chapter Two

Literature Review

This chapter reviews different literatures that are related to the subject matter. It covers the following: basic concept of cloud computing, service types, tools, deployment models, cloud computing adoption strategy, cloud challenges and benefits for the banking industry; different publications about Ethiopian banks existing ICT usages; and related articles, journals have been reviewed on cloud based service model locally and globally in order to understand how it is implemented or used in banking sectors.

2.1Cloud Computing

2.1.1 Definition

Cloud computing is a long awaited dream of transforming the Internet into an utility as R. Buyya predicts [5]. But in order to make this possible the Cloud is based on well-known technologies (such as Virtualization, utility computing or distributed computing) [6] [7] and it needed to wait for the infrastructure to be at the right level of availability and performance in order to facilitate provided services. "Today enterprises are enduring a strong pressure on cost reductions and an intensifying market competition forcing them to be more efficient, productive, agile and innovative in order to meet business objectives. Consequently there is increasing demand for technologies that help enterprises increase their customer base while reducing their costs and extending their competitive advantage" [12].

Although the basics are defined, there is not a clear definition of what exactly can be considered Cloud computing. One of the most accepted definition is given by the National Institute of Standards and Technology: "Cloud computing is a model for enabling 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."[13]

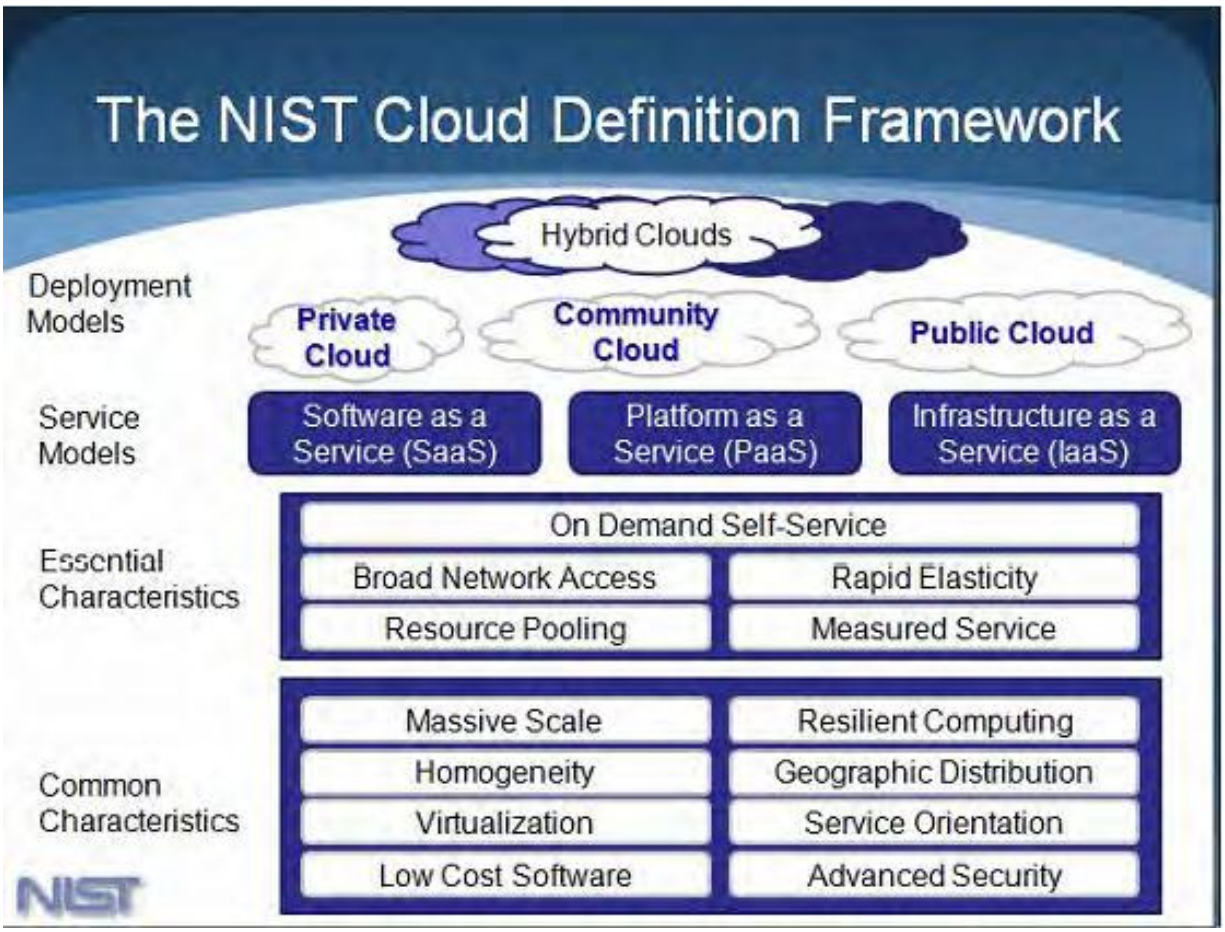

Figure 2.1: Cloud Computing Definition [13]

Cloud computing builds on the advancements in virtualization technology, grid computing, SOA (Service Oriented Architecture) and web services technologies. Before proposing the design model I need to assess how cloud computing can increase the effectiveness of the banks tasks. This evaluation may be done by collecting relevant data from different environments and services, then proposing a suitable infrastructure and deployment model for Ethiopian banks.

2.2 Cloud Computing Deployment Models

2.2.1 Private cloud

A Private Cloud, is used when the cloud infrastructure, proprietary network or data center, is operated exclusively for organizations and governmental institutions who wants to keep their data in a more controlled and secure environment, and serves their customers accordingly [8]. The private cloud allows

companies to outsource the management of their IT infrastructure while having all the control over the management of resources and its location. Private computing is easier to align with security, compliance, and a regulatory requirement, compared to other cloud environments, and provides more enterprise control over deployment and use.

Private cloud might be seen as an alternative use of cluster computing, grid computing and distributed computing to avoid the high cost of data delivery [9]. Jingyu Ding [10] proposed a framework of data center consolidation by comparing the different VPN implementation technologies. Here the Private cloud is composed by two types of resources: the resource manager and the network resource manager. These resources extend private cloud to enterprise cloud computing (is a controlled, internal place that offers the rapid and flexible provisioning of compute power, storage, software, and security services by meeting the organization requirements) by adding virtual private computing and virtual private network resource [11].

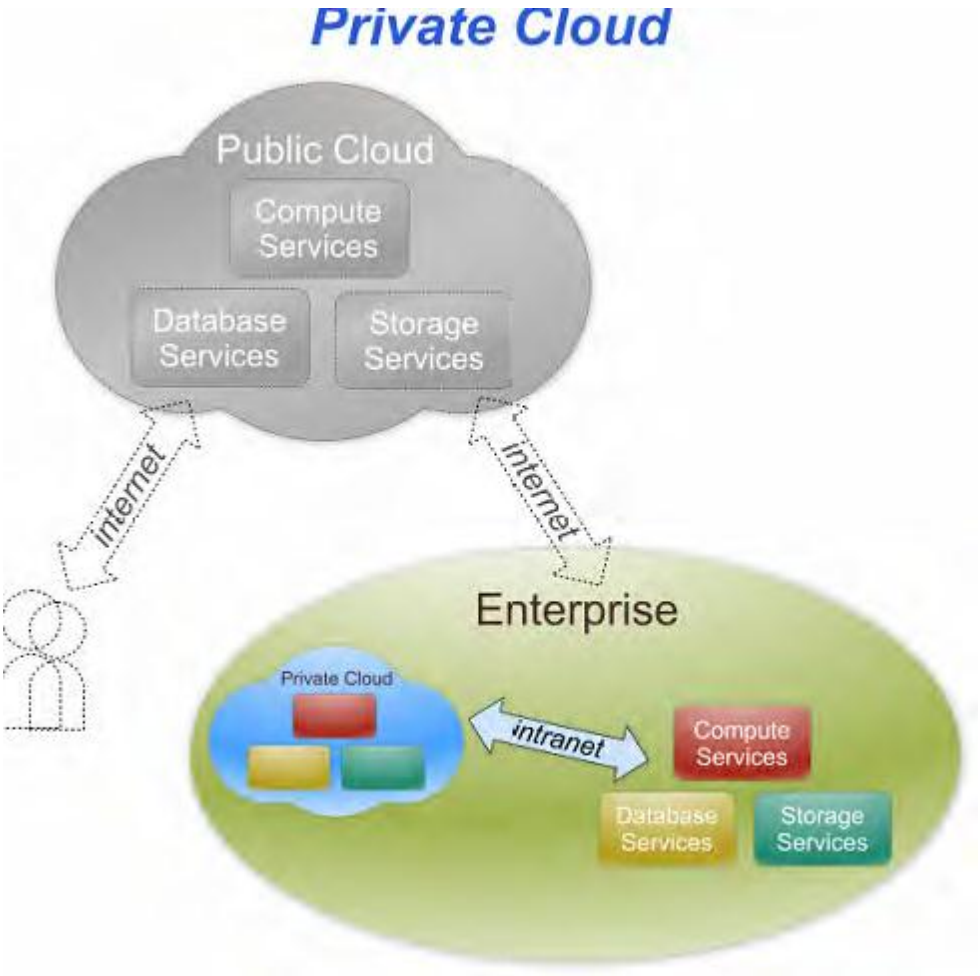

Figure 2.2 Private cloud computing [55]

2.2.2 Public Cloud

Public cloud allows users to access the cloud via interfaces. Public clouds are less secure than the other cloud models and one has to ensure that all applications and data accessed on the public cloud are not subjected to malicious attacks [1]. Performance is one of the main concern in public cloud computing, key issues when subscribing to a public cloud is that we have little control over the public because it is shared by the third party cloud provider it usually uses internet as its delivery channel [56]. By using public cloud I can avoid the costs of building and maintaining a private storage infrastructure, consumers will be billed by a service provider for the services which are accessed by the users. This feature enables a greater functionality by providing the benefits of availability (access data from anywhere) and reliability (not to worry about the backup of data).

Public cloud computing infrastructure could be used at low cost, low technical barriers and high diversity. With Multimedia technology by achieving "the resources and procedures storing and running on cloud share the same human-computer interaction interface" and this approach is clearly more flexible to achieve, it is easier and cheaper[57]. Public-cloud providers typically provide the environment by applying traditional perimeter-security approaches it will increase the potential for exploitation. Due to cyber-attacks in public clouds we need to move the security from the edge of the public cloud to the Virtual Machines [58].

The public cloud offers user access via the Internet, and cloud subscribers perform administrative activities messaging systems knowledge base system of the company, payroll, accounting and finance, human resource, and project management in this environment that needs high day to day activities of users/employees. This paradigm in itself introduces security risks because this remote access provides exposure to potential cyber-attacks. Although these vulnerabilities increase the threat space, other concerns pose an equal, if not greater, security threat.

In Public Cloud organizations do not need to pay a large upfront cost in terms of money (e.g., for hardware purchase) or space (for building data center) before launching services, or over-provision to accommodate future or demand as the time goes by. Instead, the cloud " pay-as-you-go" charging model enables the customer to pay for what he/she actually uses and promises to scale with demand [59].

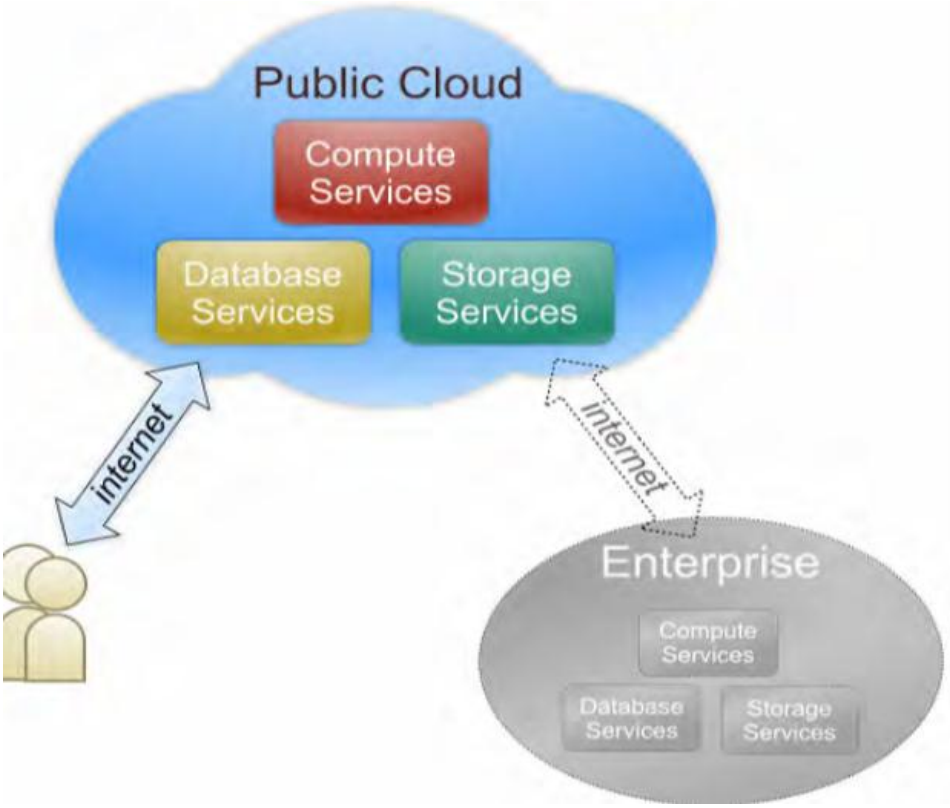

Figure 2.3 Public cloud computing [55]

2.2.3 Hybrid Cloud

Hybrid cloud provides virtual IT solutions by mixing of both public and private clouds using scalable resources and virtual application. Hybrid Clouds offer more secure control for data and applications and allow various parties to access information over the Internet. It also has an open environment that allows to interfaces with other management system. Hybrid cloud makes the customers agree to a viable and cost-saving methodology to make a great use of public cloud services along with their private cloud services. The cost will be measured by considering the bandwidth, storage, power, cooling, physical plant, and operations of the companies [60].

In this environment the performance will be neutral while accessing the applications and services. Also the hybrid cloud exploits flexibility in the organization, as it can be a composition and combination of at least one private cloud and at least one public cloud. This environment provides more noticeable functionality by archiving information, backup functions and allowing local data to be replicated to a public cloud [61].

In the Hybrid cloud, many financial institution might prefer to keep their core data and applications within their own control to ensure its security, while hosting the non-core ones on a public cloud. Under this cloud deployment model users typically outsource non-sensitive information and processing to the public cloud, mean while keeping sensitive services and data in their control [62]. A hybrid cloud can be delivered by a merged cloud providers that combines its own resources with those of other providers. Thus hybrid cloud delivery model encompasses provisioning all components and services that are required to deploy services (e.g. Hardware, network services, operating systems, databases, middleware, applications, and third party service provisioning).

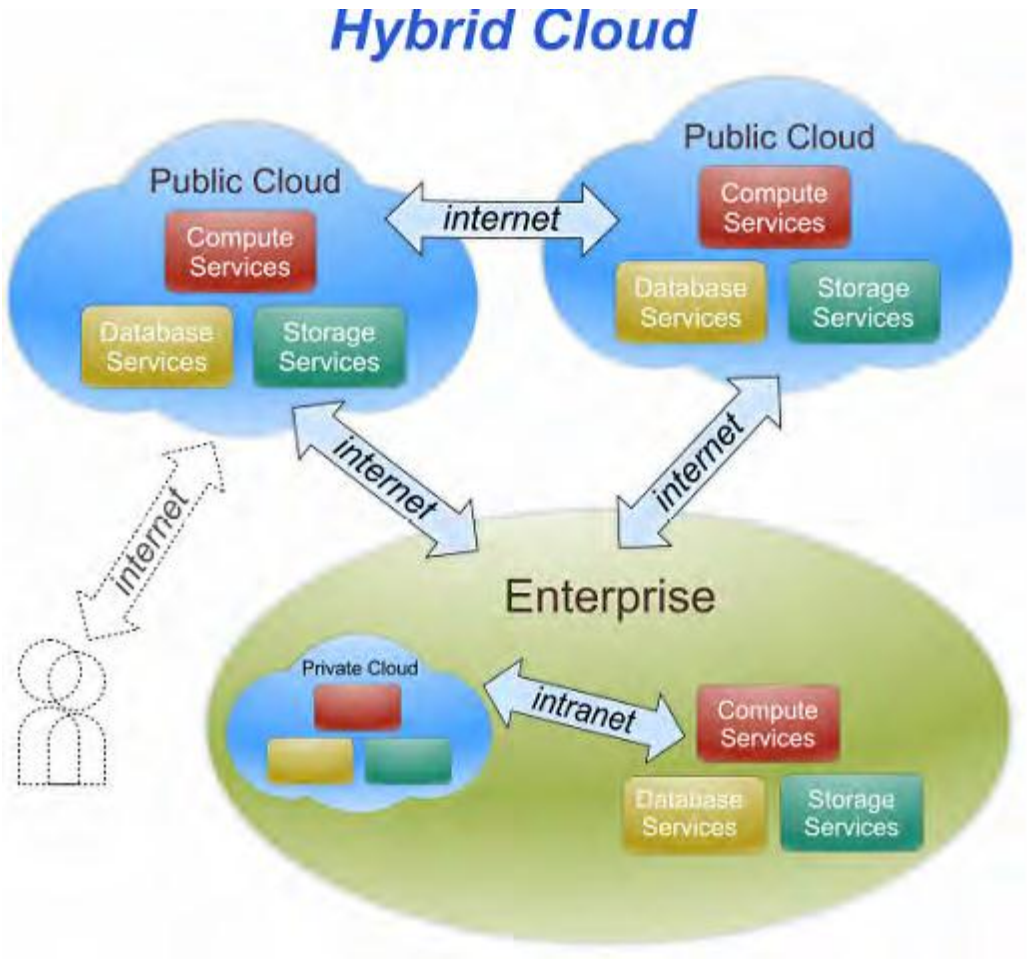

Figure 2.4 Hybrid cloud computing [55]

2.2.4 Community Cloud

A Community Cloud is shared only to the members of the community that has same concerns but it is not shared by the general public [63]. It is available only to the followed members of a community, it can be set up where the organization has similar requirement at all costs and for sharing their infrastructures. Community Cloud Computing has the advantage of no control of vendors in Cloud Computing. Compared to other cloud, Community Cloud is as much a social structure as a technology paradigm, because of the community ownership of the infrastructure [63].

Community cloud is a resources community formed by services, hardware resources and other network resources for organizations and institutions that have the same interest. Community cloud users can easily use the services of resources from different members, without knowing the specific location where the service is running [64]. Community Clouds will probably require more bandwidth than public cloud but can take advantage of the ever-increasing bandwidth and deployment of broadband [65].

An example is Wikipedia adopts Community CC; it would be dispersed throughout the Community Cloud alongside other services, which in this environment can be as simple as a webpage or complex. Examples of complicated tasks, such as editing a Wikipedia page, will require an update to the distributed storage of the Community Cloud, achieved by transmitting the new data through its network of nodes, most likely resulting in an eventual consistency mode. I can secure the community cloud by using Virtual Interacting Network Community [64].

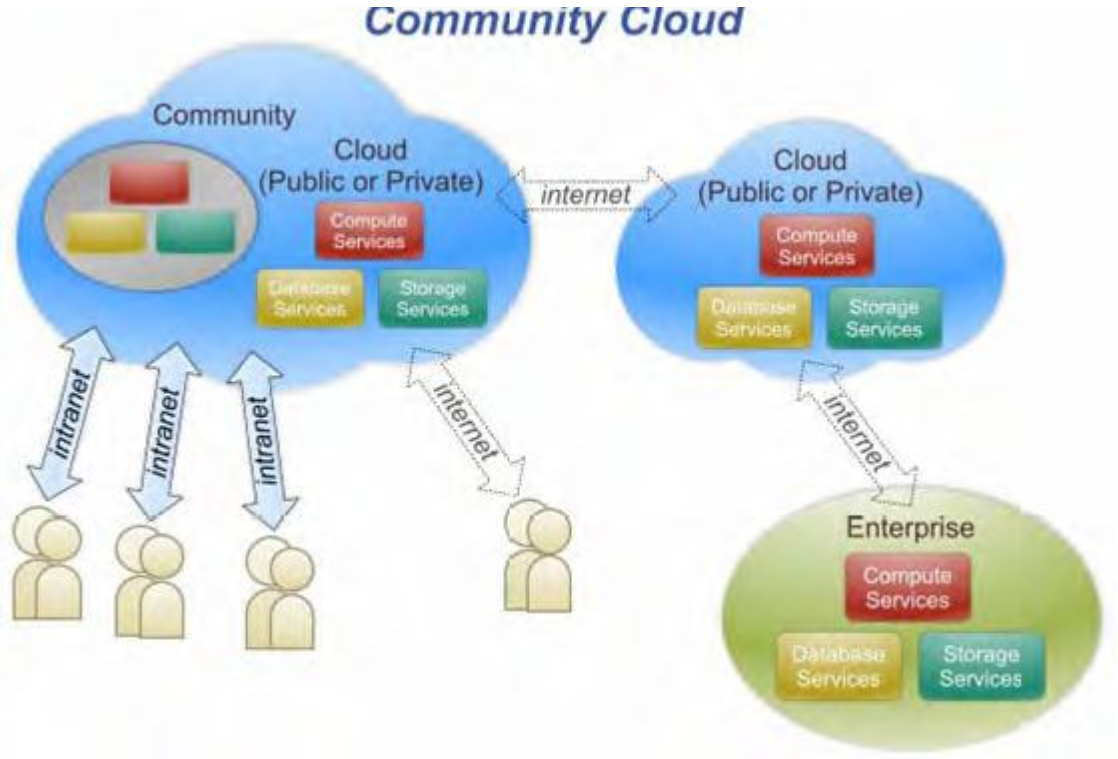

Figure 2.5 Community cloud computing [55]

2.3 Cloud computing services

Cloud computing, in short, means the use of IT infrastructure as a service and that service can be anything from using someone network infrastructure to renting raw hardware, or using third-party APIs. Cloud computing services provides financial institutions the option to move from a capital intensive approach to a more flexible business model that also lowers operational costs. The main cloud services provided by cloud providers, can be grouped together in to three main categories. The following section will discuss them briefly.

2.3.1 Infrastructure as a Service (IaaS)

The first of the three cloud service models mainly focuses on the infrastructure. The aim of infrastructure as a service (IaaS) is to attract companies by lowering their total cost of ownership of the information system's assets. Companies acquire processing, storage, networks, and other fundamental computing resources where they can deploy and run arbitrary software (e.g. operating systems or applications). The customer cannot manage or control the cloud infrastructure but has control over operating

systems, storage, and deployed applications; and with possible limited control of some networking components such as firewalls. [14].

The main advantages for enterprises using this type of services are considered to be ability to rapidly scale, instant deployment, lower total cost of ownership, and predictable uptime [15]. However, a key factor has been determinant for the expansion of the model: cloud bursting, which has been the greatest value for costumers. It means that when the most compute resource is needed it off-load tasks to the cloud. In other words, companies do not have to acquire assets to cover the most demanding runtimes, but transfer some of the running processes to cloud infrastructures when needed. In this way, businesses won't need to invest in additional servers that only run at high- or full capacity two or three times in the year, which allows them to invest in more economical solutions [16]. In addition, IT departments must have the capacity to come up with software that handles the ability to re-allocate processes to the cloud. Some companies, like IBM offer specialized cloud-bursting software for their cloud computing services [17]. The main cloud-infrastructure services are based on three major resources: computing power (similar to a CPU), computing memory (similar to RAM) and storage (similar to a Hard Disk Drive). All providers in the market offer these three characteristics. Many other attributes like software licensing, bandwidth, inbound or outbound transfer of files to the cloud, or accessible IP addresses also have to be included in the service. Offering more specific characteristics or adding them at attractive prices let infrastructure-as-a-service providers to differentiate from their rivals in the market.

The main economic advantages of customers that uses infrastructure as a service are: 1) Lower purchasing costs, because providers often have greater purchasing power than single companies and the pooled resources are redistributed in the bandwidth, 2) Avoiding technology obsolescence, as providers are very likely to acquire the latest technologies, and 3) Unparalleled expertise, due to the fact that providers recruit top talents, which may be unavailable economically to some companies. [15].

2.3.2 Platform as a Service

Cloud computing has evolved to include platforms for building and running custom web-based applications, a concept known as Platform-as-a-Service. cloud-computing model in which the vendor provides the infrastructure to the costumer, who acquires the capability to deploy its own-made web applications or acquired ones, using programming languages, libraries, services, and tools supported by the provider. The user can configure settings for the application-hosting environment, but has no control on the underlying cloud infrastructure [14]. It means that it offers developers the chance to build and deploy web applications on a hosted infrastructure. Moreover it can also be used to, host, maintain and test applications, covering the complete life cycle of building and delivering web applications and services.

Platform as a service consists of two basic elements. The first one is the computing platform, place where software can be launched consistently as long as the code meets the standards of that platform, so that the applications deployed in the cloud fit the current computing platform of the provider. The second is the set of applications that will assist in the development process as well as the deployment of the application [17]. In contrast to software as a service, this model allows customers to develop their own applications rather than getting them, achieving a higher level of customization. The adoption of platform as a service has been slower compared to software as a service, because of the programming languages, that have different options among the main providers, but not a standardized solution. Also the transition from traditional on-premise applications development platform can be a tough issue, as the new programming models have to be learned [66]. The actual most important providers in the platform as a service market are Force, Caspio, Google app engine, and Microsoft azure. Gartner group argued that in 2008 the platform as a service market represents approximately 1,5% of the total application development market, and expected this value to grow up to 10% by 2013 [59].

According to Forrester research, Platform-as-a-service will become a middleware platform alternative. Reintegrated and, in many cases, simplified platforms for the development of general-purpose business applications will become a serious alternative in the near future for developing custom applications. Also independent software vendors will also find them a highly attractive option for delivering software as- a-service applications [67].

2.3.3 Software as a Service (SaaS)

The first implementation in cloud services was software-as-a-service. It is a multi-tenant platform and it is also knows as software on demand. It is an application hosted on a remote server which is accessed through Internet and is a low-cost way for businesses to have specialized software that multiple users can operate.

It is also a model of software, where a provider licenses an application to customers as pay-per-use model [17]. SaaS runs on the hardware from the licensor or somewhere in the cloud and provides the maintenance, installation and management of the software. I can also say it is a software application functionality offered/consumed over the internet with minimal or no software installation that is required to access. Some of the providers of SaaS are Force.com, AT&T, and Media Temple and so on; most of these organizations provide hosting services.

2.4 Characteristics of Cloud Computing

There are 7 essential characteristics of Cloud Computing which explains there relation and difference from the traditional computing [14].

- **On demand self-services**: provisioning computing resources such as email, applications, network or server service can be provided without acquiring human interaction with each service provider. Cloud service providers providing on demand self-services include Amazon Web Services (AWS), Microsoft, Google, and IBM. Salesforce.com, New York Times and NASDAQ are examples of companies using AWS (NIST)
- **Broad network access**: computing facilities that are available over the network can be accessed from anywhere over the network using any sort of thin or thick client platforms like Smart phones, personal computers, laptops and PDAs.
- **Resource pooling**: The provider's computing resources are pooled together to serve multiple consumers using different physical and virtual resources dynamically assigned and reassigned according to consumer demand. The resources include among others storage, processing, memory, network bandwidth, virtual machines and email services.
- **Rapid elasticity:** allows for rapid capability provisioning, for quick scaling out and scaling in of capabilities. The capability available for provisioning to the client seems to be unlimited and that it can be purchased as demanded. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time.
- **Measured service**: Cloud computing resource usage can be measured, controlled, and reported providing transparency for both the provider and consumer of the utilised service. Cloud computing services use a metering capability which enables to control and optimise resource use. This implies that just like air time, electricity or municipality water IT services are charged per usage metrics – **pay per use**. The more you utilise the higher the bill. Just as utility companies sell power to subscribers, and telephone companies sell voice and data services, IT services such as network security management, data center hosting or even departmental billing can now be easily delivered as a contractual service.
- **Multi Tenacity**: is the 6th characteristics of cloud computing advocated by the Cloud Security Alliance. It refers to the need for policy-driven enforcement, segmentation,

isolation, governance, service levels, and chargeback/billing models for different consumer constituencies. Consumers might utilize a public cloud provider's service offerings or actually be from the same organization, such as different business units rather than distinct organizational entities, but would still share infrastructure.

- **Virtualization**

  It is an essential technological characteristic of clouds which hides the technological complexity from the user and enables enhanced flexibility (through aggregation, routing and translation). More concretely, virtualization supports the following features: virtualization can make it easier for the user to develop new applications, as well as reduces the overhead for controlling the system by giving ease of use. Virtualization allows for higher interoperability by making the code platform independent that makes it independent from infrastructure. By exposing a virtual execution environment, the underlying infrastructure can change more flexible according to different conditions and requirements, for assigning more resources, etc. Services can be accessed independently from their physical location of the user and the resources, which showed its location independency.

2.5 Cloud Computing Benefits for Banks

Cloud computing can help financial institutions to improve performance in a number of ways. Cloud computing can enable banks to turn a large up-front capital expenditure into a smaller, ongoing operational cost (including salaries and energy costs). Cloud allows banks to reduce the heavy investments in new hardware and software to expand internal IT infrastructures, while it allows customers to pick and choose the services required on a pay-as-you-go basis offered by cloud providers.[1]

Cloud computing enables emerging market banks to have low cost startups by allowing them to rent resources offered by cloud providers or by establishing collaboration with matured infrastructure legacy banks instead of having their own sets. While, large enterprises can take advantage of cloud computing as a tactical solution to face seasonal peaks without spending big sums to acquire resources that will be idle for most of the time [16].

2.6 Information Technology and banks

2.6.1 The importance of IT in banking

According to Wikipedia bank is a financial institution and a financial intermediary that accepts deposits and lend it to borrowers directly to individuals, companies, or entities or indirectly through capital markets. A bank is the connection between customers that have capital deficits and customers with capital surpluses. Due to their influence within a financial system and the economy, banks are highly regulated in most countries. Most banks operate under a system known as fractional reserve banking where they hold only a small reserve of the funds deposited and lend out the rest for profit.

Banking has undergone many transformations during its long history, going from scarce temples guarded by mysticism and fear of all knowing gods, to the high tech digital world of today where algorithms play the role of guards to personal valuables. The first banks were the religious temples of the ancient world, established in the 3rd millennium BC. They would safeguard goods and precious metals, before the invention of any currency. By 1760 BC the first laws governing banking appeared [68]. Ancient Greek temples conducted financial transactions such as loans, deposits, currency exchange, and validation of coinage [69].

In the last years of 20s century a new technology was introduced to aid banks, in the form of computational electronic machines and later on electronic storage and payments, the emerging of computer. As a result this generated lucrative years and banks profited during the boom years of the 1990s and into the tech boom and bubble. When the tech bubble burst, it precipitated a string of new legislation to prevent conflicts of interest within banks. Investment banking research analysts had been actively promoting stocks to investors while privately acknowledging they were not attractive investments in developed world. This kind of scandals spread across America in the late 1990s [70].

This blast of IT is changing the banking industry from manual paper work and total dependency on branches to' digitized and networked banking services. It has already changed the internal accounting and management systems, and the service delivery systems of banks used to interact with their customers. Delivering banking products and services using this system can be more convenient and effective in timely manner than ever before. Banks with the ability and the willingness to invest and integrate in information technology dominates in the highly competitive global market.

2.6.2 Challenges of current IT systems on banks

One of the challenges currently is rapid geographical expansion of banking market has forced banks to replace their off-line and branch based systems by an on-line system linking all branches to the head office through the telecommunications network [71].The highly requirement , broad computing needs of customer transaction history requires big and quite increasing transaction-data storages, and high-performance computing capacity needs for running complex algorithms and a high number of computations.

The other factors considers as challenges is lack of proper planning for the development of any new applications [71]. A computerization plan is the basis for implementing successful information technology solutions. To be relevant, these plans have to be linked closely to organizational visions, strategies, objectives, priorities and core processes.

The highly competitive world that brought bought by Technology enforces banks to offer wide range of services such as mobile banking, Agent Banking, ATMs, POS and others at once. These require banks to respond very actively in the marketplace in introducing new products and services all together.

The need for structural changes (Business Process Reengineering) at banks to properly manage staff expenses which can lead to more profitable also can be considered as a challenge in the current banking system.

The increased demand for risk analysis adds to the loads on in-house systems, forcing increased capacity and increased capital investment costs. A multi-sourced infrastructure allows faster resources provisioning than building in-house infrastructure [71]. Building data center infrastructure has the limitations to provide flexibility to schedule necessary simulations when business requires it. Additionally, there are lacks of mechanism for on-demand scaling solution that can enable superior customer experience and capacity. So banks should upgrade or change their datacenters when it reaches its peak position and times the market need more. This leads the banks to invest highly on IT to procure and provision the infrastructures.

In addition telecommunications infrastructure have big impacts on a systems that need real- time communication for delivering banking services in developing countries. Telecom infrastructure in the banking sector is a major factor to the success or failure of any banking services in this days. The result of such situation is a delay in implementing new services and products like remote banking, electronic funds transfer, and real time bank information systems. This has also an effect on the reliability of the services already implemented like ATMs POS Machines that needs real time communications.

2.7 The Future of Cloud Computing at Banks

The rapidly changing customer relationship management task, the emerging generation of cloud based socially-driven money management tools, the emerging collective cloud based service sharing in to joint venture, scale of IT infrastructure, and competitors' pressure will influence cloud computing adoption for banking industries in the future [63].

The relationship between consumers and their providers of banking services and products are rapidly changing from time to time. Consumers' migrations to digital, mobile and contactless payments will affect the buying habits, channels and customer services in all markets, and impact all consumer-facing industries. Cloud computing will make these services more convenient, more accessible, easier to use, and more personalized to the individual's needs and lifestyle. Currently many banks at developed countries are focusing to advance the IT stacks at all level on IaaS and/or SaaS, having virtualized their infrastructure and started to use SaaS for undifferentiated activities. Additionally banks will continue to ramp up effort to win customers not just from banks, but from others to respond the competitor pressures in order to avoid disintermediation by investing in capabilities around social media, analytics, and targeted product and service bundling [63].

Banks can take the same approach with their own systems and processes. Scale of IT infrastructure will also influence cloud computing adoption. Newer and smaller banks built on client/server architectures have less overlapping legacy systems and infrastructure, and will therefore be faster to adopt cloud technology higher up the stack. Underscoring the fact that cloud computing adoption is not an all-or-nothing choice for newer and matured market banks.

Moreover, banks can collaborate in the same ideas/activities in a joint venture using Community in a closed group community. These joint ventures could provide shared services and products that interact with customers in more engaging ways while simultaneously freeing banks from repetitive cost and routine work. Collaborative joint ventures could also be suited to areas that needs special attention like the regulator of the banks. And also integral to core banking activities but not have a difference with customers, such as security can be shared with other banks and operated via a joint venture private cloud called community cloud [63].

In the near future cloud computing will be the most anticipated aspect of IT. Thus no industry including banks can afford to let it go. But then again its influence will vary in each case. Competition, collaboration, and convergence will impact future banking products, services and technologies.

2.8 Existing IT practice in Ethiopian banking sector

All banks in Ethiopia are using networked banking system at enterprise level. They all invest sizable amount of money including the new banks for achieving the changing computing needs to deliver the banking services consistently in the market for their customers. These modern services like e-banking technologies used to provide banking services for customers are ATMs, POS Debit cards, mobile banking, Internet banking, and others technologies by using agents [75].

In this five year period, all banks started to use Core Banking Systems. The use of core banking solutions is expected to achieve a nationwide electronic payment system according to the central bank`s targets. CORE ("centralized online real-time environment") banking services provided by a group of networked bank branches [72]. Bank customers may access their accounts like withdrawal or deposits from any of the member branch offices and other channels by accessing the application from centralized data centers.

In 2009 a corporate called Premium Switching Solution (PSS) was formed by three private commercial banks - Awash International Bank S.C., Nib International Bank S.C and United Bank S.C. and recently Birhan Bank, Abay bank, Debub Global bank joined the corporation to work together and get competitive advantage by closing their gaps to customers [73]. On the other hand there is another collaboration between Zemen Bank and Dashen Bank under the “Q-Link” network the customers of Zemen and Dashen Banks are both able to benefit from ads up machines they both have [74].

Customers searching their client machines such as ATMs, POSs ended with the launch of EtSwitch on May 2016 [72]. NBE takes the initiatives to collaborate all commercial banks to form switching company which integrates all real-time and online payment systems in Ethiopia.

Continual improvement IT infrastructure and advancement of technology would assist banks` to gain the actual and expected benefits of IT. Developing a suitable model/framework for adopting new technologies that are well applicable has been the best strategy in the developed world.

2.9 Key Concepts and challenges of the transition

To understand the challenges concerned with the move to cloud for any organization an analysis of literature sources is provided in this chapter. As a general perception the National Institute of Standards and Technology (NIST) took a survey [19] and rate the challenges that are estimated from the adoption of Cloud computing. Here are the result:

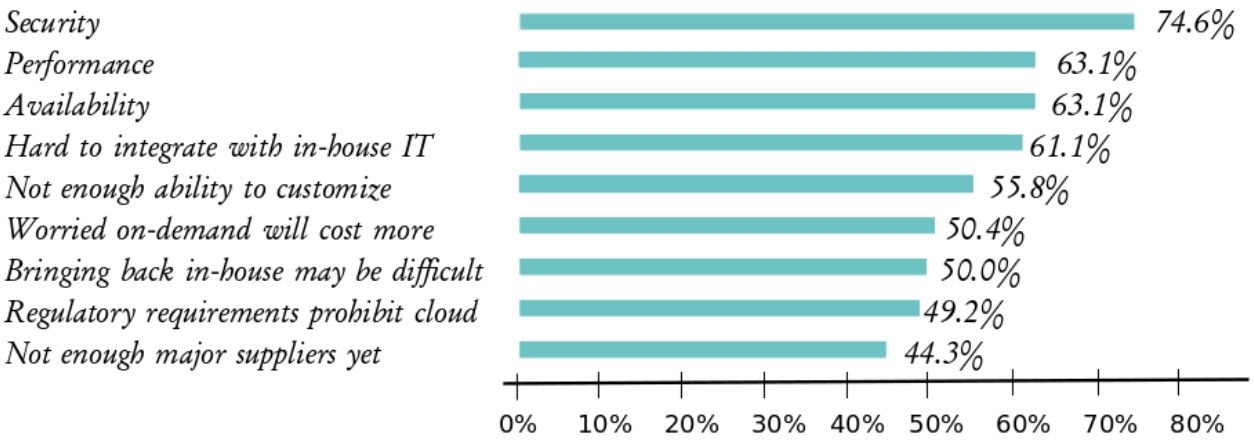

Figure 2.6: Results for NIST Cloud Challenges Survey [19]

For broader range of coverage for possible transition difficulties, I group them according to their areas of influence and to point out each of them in this thesis, challenges are classified into:

- Technological challenges,
- Organizational challenges,
- Governmental challenges.
- Social challenges
- Security,

2.9.1 Technological Challenges

This refers to the maturity of the technological development in Cloud computing and the possible inconveniences that this technology might impose on any user, including financial institutions. On top of this security risks, that are expressed more from the perspective of a future Cloud user company, there are also core security challenges in the Cloud that must be taken into consideration due to existing technology like:

- Incidences caused by Insecurity in the Cloud. There have been a lot of proved security attacks [20] on different Cloud computing providers such as Google (Gmail, App Engine), Amazon Web Services (Amazon S3), and Salesforce.com (Salesforce.com). It might be a matter of time or intellect that Cloud computing providers will be hacked and significant damage will occur.

- Insecurity from the choice of Cloud provider. Cloud computing, being a distributed architecture, this would indicate that more data in transit than using traditional infrastructures. Images are distributed across multiple physical machines, between Cloud infrastructure and remote web clients. Also some Cloud providers use data center host editing that is supposed to be implemented in a secure Virtual private network (VPN) connection environment. It can happen in practice that some organizations using different Cloud providers end up with those providers using different security implementation rules that may lead to security loophole for the customer data.

- Vulnerabilities in the Virtual Machine. The collocation of multiple virtual machines increases the risk of virtual machine-to-virtual machine compromise. Localized virtual machines and physical servers use the same operating systems as well as enterprise and web applications in a Cloud environment, thereby increasing the threat of an attacker or malware exploiting vulnerabilities in these systems and applications remotely. An outside attacker could place a malicious VM in Cloud that can pretend to be a valid host machine of the service provider and receive information environments from unsuspecting users. It could also snoop on the traffic within the data center. Let see an example, the hypervisor has the highest privilege in the system that hosts the virtual machines for users. A malicious or compromised hypervisor can intentionally disrupt the company's security mechanisms.

- Denial of service attacks other reason that needs special attention to security in the Cloud is the threat to bring down a Cloud system with a Distributed Denial of Service (DDoS) attack, which means attacking a web server with a flood of messages, all at the same time. There are DDoS attack tools, like Agobo and other worms that, if used creatively, can cause great disaster to the Cloud.

2.9.1.1 Portability Limitations

Sticky services are services that an end user may have difficulty transporting from one Cloud vendor to another. These services are the biggest worries of any executive. No firm wants to be depended on the existence of its providers and get stuck in a Cloud, needing to rewrite its applications or to suffer data losses. The positive aspect is that Cloud portability tends to be a factor related to the type of Cloud one uses. [21] Here is how these problems could be presented for the three big Clouds on the market (Fig. 3.2 [22]):

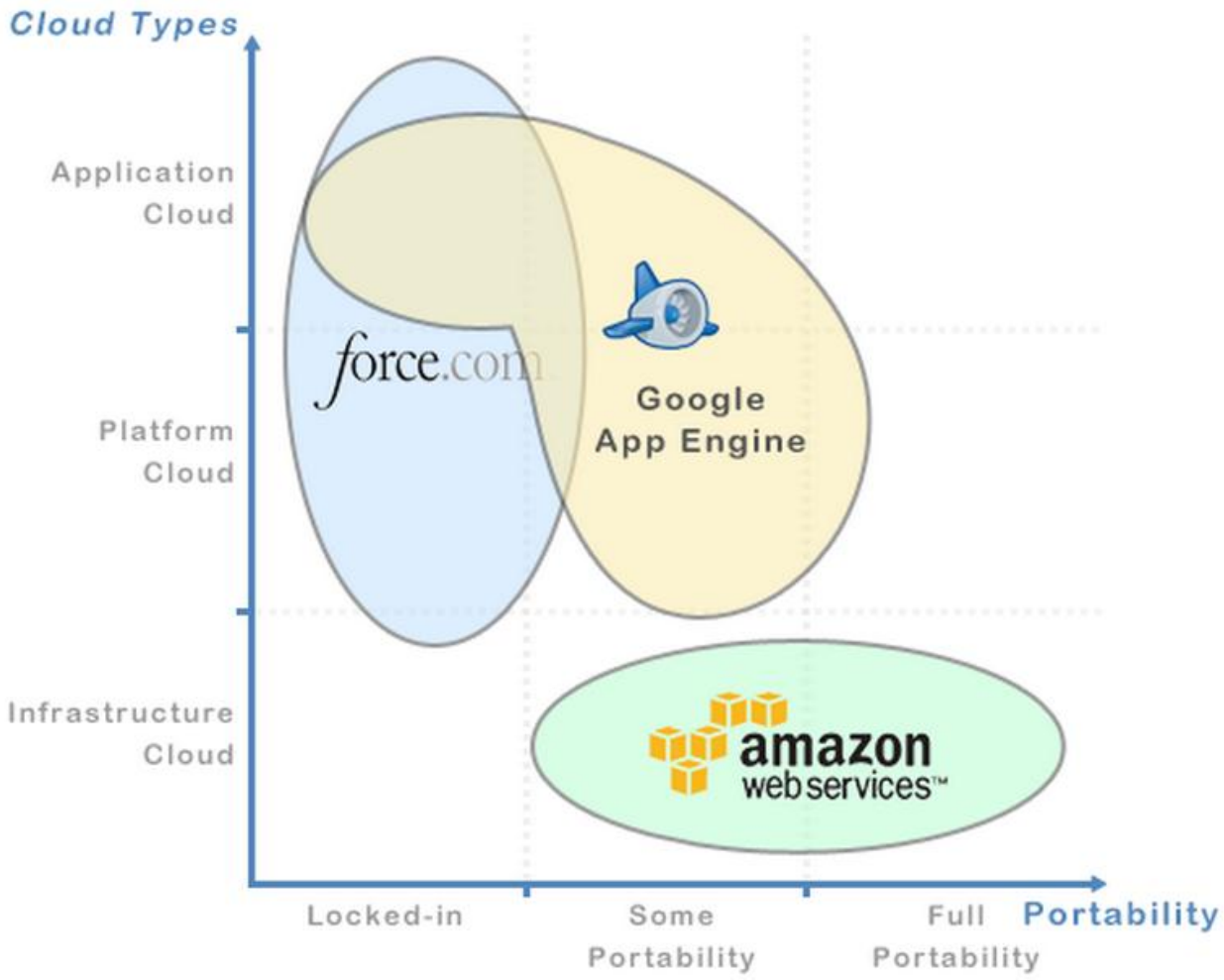

Figure 2.7: Cloud Portability [22]

- Force.com has a very powerful and highly integrated platform and application Cloud, but it is depended on proprietary technologies similar to Java, and its own SQL/ORM layer. This allows the application to take full advantage of Force.com scalable architecture and to integrate deeply with SalesForce.com. However, for those of you implementing a standalone application, it is not a portable platform.

- Google App Engine. Google supports Java on its platform Cloud, but there are still some restrictions. Most of the common Java libraries and frameworks can be used on the Google App Engine. The only inconvenience might be created by the data layer. Google App Engine uses JDO as a data layer or a subset of JPA. JDO works fine with some applications, but might be hard and costly to adopt for enterprise application. JPA support is not complete yet. Therefore, moving an

application from SQL/Hibernate to App Engine is manageable for a well-architected application, especially with JPA used in both environments.

- Amazon WS does not provide any platform Cloud service. Therefore it does not restrict application developers to any technology, but SaaS developers will have to develop their customized, highly-scalable architecture.

2.9.1.2 Network Limitations

The main mechanism that puts Cloud Computing practical is network. Any issue regarding network connection will seriously affect and interrupt all Cloud activities. Therefore I encounter inherited risks and emerging ones. Specially in third world countries like Ethiopia network problem may be the biggest problem that one could face to implement cloud computing.

On one hand there is latency and Availability. Latency has always been an issue on the Internet. Performance within the Cloud doesn't mean much if it takes forever for the results of that performance to show up on the client. First and for most Internet Service provider in this case Ethio Telecom should make Internet more available, efficient, and reliable. Another thing using a well-planned infrastructure and smooth applications that understand where and how they're running.

On the other hand, technology advancement can impose its own requirements. For instance the new applications must take into consideration IPv6 because I are almost run out IPv4 addresses. Cloud computing, due to its host capability needs, which can appear by the thousands at once, will guarantee the need for IPv6 address pool and technical flexibility.

2.9.2 Organizational Challenges

Every organization that wants to adopt Cloud should take Organizational Challenges in to consideration generated by both its profile, and special compliance needs or by its existing structure, policies and clients.

2.9.2.1 Compliance

An organization needs to make sure it is compliant with internal and external rules and regulations. Because of this, when considering Cloud computing, the first things to understand are regulatory and legislative obligations, depending on industry or geographic location. Some examples include PCI DSS (Payment Card Industry Data Security Standard), and ISO (International Organization for Standardization) standards.

The Cloud provider will not explain which are applicable for what type of organization. It is possible that the general rules any Cloud services provider needs to apply in its own data center are enough for the needs of the organization requesting this service, but also it might be the case that not all the requests are meet in a standard offer by the chosen Cloud provider, therefore this is to be clarified since the beginning.

In the case of financial institutions, due to the nature of the transferred data and the environment they operate in, there are specific rules for each institution type. The general term to describe rules and regulations in this context is compliance risk. Compliance risk is sometimes referred to as integrity risk, because a bank's reputation is closely connected with its adherence to principles of integrity and fair dealing. Banking supervisors must be satisfied that effective compliance policies and procedures are followed and that management takes appropriate corrective action when breaches of laws, rules and standards are identified [23]. One of the main component that insures the compliance is the IT system.

2.9.2.2 Trust in Cloud Provider

Trust = Control + Visibility [24]

All firms has its own way of choosing partners. This is not different in the case of Cloud providers. But trust in the Cloud provider is very important for a good cooperation. In order to ensure that the Cloud provider is a suitable partner, most organizations perform audits that make sure all the agreed upon requirements are fulfilled.

A Cloud provider is a commitment that an organization takes for a long period of time. Although there is the possibility to change the provider, there are lots of complications with the existing technology and thus is preferable to develop a degree of trust before implementing Cloud into any institution.

The client organization is going to work with a Cloud provider in everyday activity that requires a high degree of integration at the IT level and also at business level, having long term consequences, so trust is a key element for this decision. Even so, trust is still an element that needs to be developed. There are some

ideas to address this problem like the existence for a Cloud Trust Authority, an independent entity that provides standardized control and visibility services across multiple compatible service providers [24].

2.9.2.3 Structural and Internal Policy Change

Whenever adopting Cloud there are some new policies to be implemented, as with any other third-party management of information resources. This might include and are not limited to:

• Security and privacy policies

• Auditing policies

• Software licensing policies

• Acceptable use policies

As of these policies might impact the internal policies that the organization implements. For instance the use of Cloud might restrict some rights that the users had previously or might give a different role to the administrator of the system, resulting in the development of new internal policies to deal with this new position. This may lead to the existing internal regulation can be made obsolete.

Concerning the structural changes, they might occur if the new software solution integrates different delivery channels in order to provide more coherent offer to the end user. For example, the customer centric approach reunites multiple product divisions within an institution and thus it might influence the existing structure suitable to such an approach. Although this kind of changes must be taken into consideration, they are not a direct consequence of Cloud adoption.

Adopting Cloud will have direct consequence on structural change in the internal IT division. Nowadays almost all financial firms has its own data center, the main challenge is to restructure the existing resources and to reuse them in different tasks.

2.9.3 Social Challenges

Financial institutions are highly dependent on the socioeconomic environment they have to operate in, thus social acceptance and conception is a very important factor that should be looked for.

2.9.3.1 Social Hesitation

Social hesitation is mainly created by an important difference that exists from the perspective of the client. On one hand, a financial institution is an organization that any client entrusts with its most personal data and expects it to keep it safe and not use it without permission or in any other way than the one agreed

upon. On the other, the clients tend to associate Cloud computing with Social Media and Social Networking [25].

For instance, if the client of a financial institution is used to input personal data in a local application, even though this data will be transferred to the bank via the Internet, it will find it very difficult to trust a similar application that runs in a browser, only due to the fact that the Internet is not to be trusted. Users seek security in Internet applications because trust is often not justified. The more security is guaranteed, the easier it is to have trust. [25].

2.9.3.2 Security Concerns

Security concerns are arises by the nature of the data a financial institution exchanges with its customers. Although user are generally familiarized with the role of Social Media and Cloud solutions in their daily activities, questions like "What do I want others to know?" [26] And "Who has access to my information?" [26], are major security concerns when combining Cloud and banking.

These concerns that users express are evidenced also through the large number of compliance regulation a financial institution must respect. Until these concerns will be put to rest, the adoption of Cloud computing by the financial institutions will remain an issue.

2.9.4 Governmental Challenges

Legislative initiatives should be placed to assist adoption of Cloud computing by the financial institutions. Since the technological approach is in its early stage, not all the angles have been explored and legislated. This fact gives way to governmental challenges. Although it is not yet well presented Cloud computing legislation form in Ethiopia, some of the most challenging facts when it comes to Cloud computing legislation are well presented in developed countries [27] and it can be seen as:

2.9.4.1 Legal Obligations in Multiple Jurisdictions

Legal issue is created due to the fact that sharing and transferring sensitive financial data within the Cloud, the inability for anybody to easily say where the data is or has been, is the key problem. An obvious problem is "trans-border data flow". For instance under the EU Data Protection Directive, unless they take certain steps, organizations are prohibited from transferring personal information to countries that do not provide the same level of protection with respect to personal information of EU residents. Unfortunately,

Cloud providers might not be able to make any contractual promises to their clients because in many cases they cannot say which countries data will be transferred to or from [27].

2.9.4.2 Security under the Law

There is also an issue called "reasonable security" and “potential liability” for security breaches in the Cloud. Generally speaking a company outsources the handling of personal information to another company, but it is still responsible for the information. Making sure that the Cloud provider has a sufficient level of security, a multitude of audits and certifications are in place should be well thought. Nevertheless, it is highly important to establish from the very beginning what liability each company can face when there has been a security breach in the Cloud resulted in the theft or harm of valuable or protected data [27].

2.9.4.3 Electronic Evidence and Disclosure

Utilizing the Cloud can be problematic in the lawsuit context. First off, when lawsuit arises and a lawsuit hold is initiated, the organization will have to deal with a third party Cloud provider in order to get at the information relevant to the lawsuit.

In addition, considering that multiple copies of data may be created, stored, recompiled, dispersed, reassembled and reused, the idea of what constitutes a "record" or a "document" for evidentiary purposes may be difficult to grapple with in the Cloud [27].

American Patriot Act can be another reason of concern [28]. In the year 2001, this law stretched out the powers of the American National Security agencies to help out in their efforts in gathering information in connection with anti-terrorism activities. Therefore, if probable cause is established, an American firm can be asked by national security agencies to disclose private information hosted in their data centers.

2.9.5 Security

According to NIST security is major concern with many possible Cloud customers. As a result Gartner, a well-known information technology (IT) research and advisory company, tried to divide Cloud computing security risks into seven specific issues [29]:

1. **Privileged user access.** Sensitive data processed outside the enterprise brings with it an inherent level of risk, because outsourced services bypass the "physical, logical and personnel controls". Therefore any

company should ask its providers to supply specific information on the hiring and oversight of privileged administrators, and the controls over their access.

2. Regulatory compliance. At the end customers are responsible for the security and integrity of their own data, even if it is held by a service provider. Cloud computing providers should be subjected to external audits and security certifications as same as traditional service providers used to.

3. Data location. The location of the processed and stored data will not be provided by the cloud , so it advisable to ask providers if they will commit to storing and processing data in specific jurisdictions, and whether they will make a contractual agreement to obey local privacy requirements on behalf of their customers.

4. Data segregation. Cloud environment is shared by its nature, the data is shared alongside data from other customers, hence the Cloud provider should come up with evidence that encryption schemes were designed and tested by experienced professionals. Encryption accidents can make data totally unusable and can complicate availability.

5. Recovery. The question of what will happen to your data if a disaster occur should be answered by Cloud provider. Replication across multiple platforms is crucial under this circumstances.

6. Investigative support. Investigating inappropriate or illegal activity may not seem possible in Cloud computing. Especially Cloud services are difficult to investigate, because logging and data for multiple customers may be co-located and may also be spread across an ever-changing set of hosts and data centers. Therefore is imperative to get a contractual commitment to support specific forms of investigation, along with evidence that the vendor has already successfully supported such activities.

7. Long-term viability. The ideal scenario is that Cloud provider will never go broke or get acquired and swallowed up by a larger company. But you must be sure your data will remain available even after such an event.

CHAPTER 3

Research Methodology

Research is a systematic way to find solution to problems. Qualitative, quantitative and mixed methods are the basic types of research methods. In this chapter, the methods used to accomplish the work are presented, together with the process of literature review and interview.

3.1 Research Design

The research approach used in this thesis is qualitative research method. Halper [18] defines qualitative research as "a form of systematic empirical inquiry into meaning". By systematic, it means "planned, ordered and public", following rules agreed upon by the members of the qualitative research community. By empirical, it means that this type of inquiry is grounded in the world of experience. Inquiry into meaning says researchers try to understand how others make sense of their experience. In this thesis, the data is collected through interviews on cloud computing, cloud environments, and cloud services. I conducted direct interviews (Face to Face interviews) in which I prepared a set of interview questions based on the research questions.

During the literature review, related research on CC has been studied focusing on different cloud environments (public cloud, private cloud, hybrid cloud and community cloud) and cloud services (IaaS, SaaS and PaaS). Different material had been used during the literature review such as: conference papers, journals, articles, and online websites are among them.

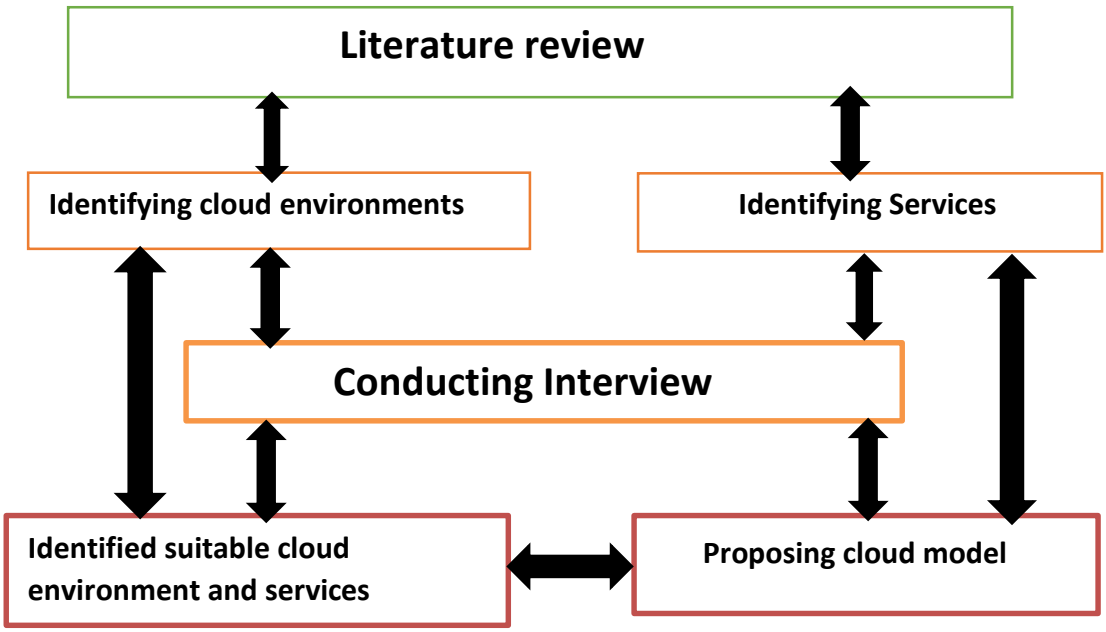

Figure 3.1: Research methodology in this thesis

The designed research method is described in Figure 3.1. All assessment including Cost, Performance, Flexibility, Functionality and security are collected from People at the banks by conducting interview finally it has been used as the input for this research. I started my work by realizing the research questions (RQ1 and RQ2), as an initial step of research and started performing the literature study. During this qualitative research, I studied about different cloud environment, cloud services with examples, security measurements and compared the different cloud environments, services with respect to the assessment made by Ethiopian Banks. This study helped me to start the empirical study for framing the interview guide for interview. By conducting interview with parallel to the literature study, I propose cloud model by getting a different set of security requirements that can be suitable for Ethiopian Banks in the future. Literature study and with the use of suggested cloud environments and services. The research methodology and research process of this thesis is described in table 3.1.

Research Process	Research Methodology
Literature Review Answers: RQ1 and RQ 2	Literature review is most important thing researchers used to gather information and I found the relevant conference papers, journal articles, reports about Cloud Computing, different cloud environments (public, private and hybrid clouds), and helps to find the relevant data on cloud services. The literature study has been done on the cloud computing environments which are explained on previous chapter and services such as IaaS, SaaS & PaaS in which the features and service offerings are also explained on previous chapter Based on this literature study I prepared the interview guide for an interview.
Interview Answers: RQ1 and RQ 2	Interview has been conducted for the purpose of identifying and gathering insight from IT experts on cloud environments, services and limitations of CC. I conducted direct (Face-to-face) interviews. These interviews help me to answer the RQ1. As it is a semi-structured interview, more questions had been extracted from the prepared questionnaire Appendix 1 to get overall knowledge of the topic. The interview conducted in each organization will be explained on the next chapter.
For designing a cloud model based on literature review and interview. I proposed a new cloud model after answering the RQ1 and RQ2. This proposed cloud model has been (checked) by the IT experts at the bank. After that, the proposed cloud model has been improved with their suggestions.	

Table 3.1: Mapping of Research Process and Research Methodology

By studying the data collected from an interview I have suggested suitable cloud environment from public, private, hybrid and community clouds based on different parameters considering cost, security, scalability, flexibility, performance and functionality of CC for

Ethiopian banking sector. The designed model in the suggested cloud environment keeps in mind issues like data transfer, storage, security and communication for Ethiopian banks.

3.2 Interview Process

Direct interview is conducted to gather the qualitative information as a part of this research. The main motive of the interviews is to know the opinion about CC, limitations of CC and other architectures currently used in Ethiopian banking sector like client server. There are different types of interview such as structured, unstructured and semi-structured interviews. Structured interview is a limited set of questions and get specific answers related to the prepared questionnaire. Unstructured interview is flexible and allows new questions other than prepared ones to be brought up during the interview depending upon the interviewee. Semi-structured is the mix of both structured and unstructured interviews [19]. In this research, I used semi-structured interview in which I asked more questions from the prepared interview guide.

3.2.1 Interview Objective

The aim of the interview is to know the opinion on cloud environments, services and limitations of CC from the IT personnel of the interviewed companies. From these interviews, I found the pros and cons of the current architecture they are using and what are their thoughts about using cloud computing in near future.

3.2.2 Interview Preparation

From the detailed study of literature review, I decided to conduct interview with the organizations using CC and organizations using other architectures like client-server.

To conduct the (face to face) interviews a set of questions is prepared and it consists of 10 questions adapted from [1]. The interview topics had been sent to the interviewee before the day of interview so that interviewee can be prepared well in advance. With this covering letter I approached the banks and got appointment for interview. The prepared guide for the interview is based on CC and the current architectures they are using.

3.2.3 Sampling Participants

The basic sampling techniques are two types: probability sampling and non-probability sampling. Probability sampling is based on the concept of random selection, whereas non-probability sampling is 'non-random' sampling. Under probability sampling design, every item of the universe has an equal chance of inclusion in the sample. Under non-probability sampling each item in the population has of being included in the sample [20].

Purposive sampling is chosen for data collection in this research, which means that the best suitable respondents were chosen from different banks because the interviewees must have the knowledge and the capacity about the subject matter, in order to understand some activity or phenomenon better and discover new viewpoints instead of making generalizations based on statistical data [20]. Under this sampling the organizers of the inquiry purposively choose the particular units of the universe for constituting a sample on the basis that the small mass so that they select out of a huge one will be typical or representative of the whole. According to Kothari [20], in purposive sampling, personal element has a bigger chance of entering into the selection of the sample. The researcher may select a sample which shall yield results in favor to his point of view.

Accordingly different people including IT Vice presidents, experts and managers from different banks were selected for interview. The selecting mechanism for interviewees were their position of authority (decision maker) by their given position or their knowledge and expertise on the subject matter for this research. The other criteria for selecting the banks were their market share all around the country, the biggest infrastructure facilities, and the regulatory body that is National bank of Ethiopia, status of maturity in the market, and infrastructure legacy in the market by categorizing them in to: large infrastructure banks, less infrastructure banks and regulator bank. The following table 3.2 shows the organization of the sample and population for the study.

Status of Banks		No. of respondents selected
Large Infrastructure	Commercial Bank of Ethiopia	2
	Wegagen Bank	2
	Dashen Bank	2
Less Infrastructure	Birhan Bank	2
Regulator Body	National Bank	2

Table 3.2 Organization of sample study

3.2.4 Execution

The interview was conducted with three Private commercial banks, one Government Commercial bank and one Regulatory Bank (National bank) based on general concepts of CC and other architectures that is being used. During the interview, as it was direct interview the data was collected by taking notes on paper and if possible by recording the interview, and time taken for conducting the interview was 30 minutes. The interview was taken by 1 interviewer with one or two interviewee of the organization. The main focus was to know the opinions of the interviewee on CC, cloud environments, cloud services and weaknesses of CC. Each informant was interviewed individually by the researcher.

3.3 Threats to Validity

This section describes the possible threats to validity of the empirical study basically interview study during the research, such as internal validity, external validity, conclusion validity, construct validity and reliability. Explanation is given for all the possible threats to validity of the interview study and also explained how to minimize the threats to validity.

3.3.1 Threats to validity for Interview study

In this research I conducted direct interview in which I had found some threats to validity. Such as external and construct validity and reliability. The quality of a research refers to its reliability and validity. In qualitative research validity refers to the relevance of the choices in terms of research approach and data collection and analysis techniques [32]. Validity means consistency of description, its explanation, and interpretation [32].

Some of the conducted interview was on banks that uses traditional client- server architecture that do not use CC for now. I found some difficulty for preparing the interview guide for interviews because, I need to frame questions for such kind of organization, by referring more articles and framed the questions to overcome this threat to validity.

During interview study the threat to external validity for contacting the organizations not using CC and approaching particular person from the organization for interview was found. The aim of the research and the use of the collected data were discussed to the interviewees to collect reasonable response. To minimize this threat, I took guidance from my advisor and approached the organizations. In order to overcome reliability threat I used to record the interviews and listen it again [32].

Chapter Four

Findings and Discussion

In this chapter, I have discussed the outcomes of the interview that is described in previous chapter. Semi structured interview is used to collect data thus it provides us both control and direction to guide through the list of questions for interview. Respondents were IT Vice presidents, Directors` and senior staff that can decide which direction banks takes regarding to replace the existing system or adopt new IT infrastructure. Purposive sampling was used to select Interviewees, two from regulatory bank, two from government owned commercial bank, and six from three private banks were interviewed. A total of ten interviewees from NBE, CBE, Dashen, Wegagen, and Berhan bank were interviewed. Hence, I will discuss the results by associating the result of interview from relevant literature findings by grouping the ideas together.

4.1 Basic formation of cloud computing adoption

The most important aspect related to adopting cloud computing systems are reasons that influence the banks to take competitive advantage or to get benefits out of it and the consequences that affects the decisions after adopting cloud computing. According to the interviewee all Ethiopian banks uses the traditional client- server based system and unfortunately they can't take an advantage from business based technological model which is cloud computing IT model because the basic difference between the two is from business point of view.

To understand better about the difference between cloud computing and the existing client-server architecture can be illustrated by ways of using the service and deployment models and its key enabling technologies of virtualization. In the case of traditional the responsible entity for security is shared between the owner of the application and the banks internal IT infrastructure including security team, whereas in cloud computing it can also lies on cloud computing provider.

Other studies show that by using cloud computing IT model, organizations can access computing infrastructures from a cloud provider that allows them to integrate and extract

computing resources work hours workloads performance parameter needed by the organizations. They can be billed by pay per use bases it means resources consumptions such as CPU hours used, memory used, and volume of data moved or tera bytes of data used [34].

In addition some researcher suggested that Cloud computing helps banks to transform their business processes and enhance their ability to grow in new sectors or regions relatively without the time and cost burdens involved with establishing a physical presence. It helps to create new markets and services to differentiate from competition and improve the ways customers' access and use the bank's products and services. Banks will have a much better ability to provide consistent service to customers across branches, geographies. These important points can motivate Ethiopian banks to adopt and implement cloud computing.

4.1.1 Risks and Advantages of Cloud computing

In Ethiopia banks currently uses traditional infrastructures, a cloud will enable users to consume IT resources in the data center in ways that were never available before. All the interviewee that employ traditional data center management practices say that making IT resources available to an end user can be time intensive. It involves many steps, such as procuring hardware; finding raised floor space and sufficient power and cooling; allocating administrators to install operating systems, middleware and software; provisioning the network; and securing the environment. Plus all the interviewee stated that data center and network resource reached its peak time banks also need to procure and install the required IT infrastructures to support the banking operation. All of these banks find that’s this process can take up to a year. Those IT organizations that are re-provisioning existing hardware resources find that it still takes several weeks to accomplish. A cloud dramatically alleviates this problem by implementing automation, business workflows and resource abstraction that allows a user to browse a catalog of IT services, get all the necessary services at reduced time. This process reduces the time required to make those resources available to the customer from months to minutes [36].

The cloud also provides a user interface that allows both the user and the IT administrator to easily manage the provisioned resources through the life cycle of the service request. After a user’s resources have been delivered by a cloud, the user can track the order, which typically consists of

some number of servers and software, and view the health of those resources; add servers; change the installed software; remove servers; increase or decrease the allocated processing power, memory or storage; and even start, stop and restart servers[37]. These are self-service functions that can be performed 24 hours a day and take only minutes to perform. By contrast, in a non-cloud environment, it could take hours or days for someone to have a server restarted or hardware or software configurations changed.

Customers wants to access any banking services everywhere and anytime using internet, mobile phone, ATM, and nearest branches possible without access limitations from any banks available in Ethiopia. Until the emergence of EtSwitch that was launched at May 2016 which is a centralized switching system which integrates all real-time and online payment systems in Ethiopia. But other than this customers needed to search bank`s channels, this wastes customers valuable time, money, and reduces their satisfaction. Employees also loaded by large routine transaction volumes, this leads high customer traffic to access the banking services from the branches and limiting the access. According to all interviewees Improving operational, financial and Customer service efficiency using IT is the strategy of all banks in Ethiopia. Nevertheless, because of the above causes banks do not address their strategic efficiency. Cloud computing will address this issue by making banking services easy to use, more accessible, and within shorter time for the customer [38].

The major barriers of cloud computing from the interviewee's point of view are network bandwidth Connectivity and reliability in Ethiopia. The biggest challenge is- internet Speed and it is still below expected speeds where prices are still too high. Thus cloud computing is challenged by the, high latency due to the network failover. Security and Privacy are also major concerns when customers entrusts his personal data, shows a very high confidence and the bank must ensure the security and confidentiality of date. By this factor cloud computing do have a lot of challenge, and this was mentioned by the founder of the cloud, Rajat Bhargav: "When you use cloud, you have a network that is open to the rest of the world. Cloud is more insecure than it was the repository data to headquarters." [39].

Another issues that is raised by the interviewees is that in line with governance, risk and compliance, the Ethiopian audit firms will have to gear up and try to form chapters for what NBE

and other governance initiatives out there regarding to cloud computing. The Ethiopian laws are not quite clear on how they will address cloud in future.

The respondents asked whether banks will decided to use IT resource and support from external public, hybrid cloud provider to support electronic banking services with greater cost saving and flexibility, and many agreed on this matter and suggests that for the time being they may want to use cloud computing for non-core application such that Email system procurement system, logistics and the like, however fear of risk to use it for core application is one of the factor that hinder the use of external cloud vendor resources and support for Ethiopian banks. Likewise the result from the interview revealed that lack of confidence with the security issue is considered as barrier for using external cloud vendor resources and support, technological barriers, such as security risk as limitation factor for the adoption of cloud computing [40].

4.1.2 Capability of the Banks

The internal capacity of the banks should be taken in to consideration when adopting cloud computing. Costs related to use IT components or services and managerial skills required to develop IT systems in general considered as organizational factor. One of the basic issue related to internal capacity to develop cloud computing model for Ethiopian Banks is, the availability of financial as well skilled human resource to implement the system.

At this moment the value of ICT is increasing for general purpose computing and specifically in banks. All banks in Ethiopia have already using the digitized and networked banking services at enterprise level IT infrastructure. Also they are investing millions of dollar for fulfilling the changing computing needs to deliver the banking services as the market demands. Core Banking Systems are applied in all private and public banks of Ethiopia. According to the NBE targets, CORE ("centralized online real-time environment".) banking is services provided by a group of networked bank such as: branches, ATMs, POS, agent, mobile and internet banking.

All the interviewees stated that banks used centralized data center that is built at their own premises. This allows the customers to go to any branch or use internet and their mobile phone to

make transaction on real time basis, this can be achieved by using VPN that is implemented by the only service provider Ethio Telecom.

Over-all, all the banking services including non-core applications can be more convenient by using Community cloud computing getting a great deal of total cost savings, small amount of time and simplified way of managing the IT infrastructure for Ethiopian banks.

4.1.3 Limitation of IT Investments and Norms

All Respondents agreed that they all have spent high investment cost on IT infrastructures for the past six years or so. Inefficient use of IT resources, lack of collaboration among banks to share IT resources, Ethio telecom infrastructure and it's inconsistency, the changing computing needs which bear compatibility problems, IT decision makers thinks that for the time being the existing IT infrastructure somehow fulfill the needs, and other related factors were the key challenges that can be considered as norm in the Ethiopian Banking industries.

Lack of short term and long term up-to-date plan for ICT service delivery strategy also considered as a limitation for Ethiopian banks` to fully harvest the opportunities presented by the latest technology. The majority of the respondents agreed up on the inefficiency regarding to the existing cost incurred on ICT infrastructure to support the non-core and core banking services.

The results from all respondents on cloud computing showed that, 'compared with the Existing IT infrastructure' to support banking services and non-core banking application would be more cost effective less time and more manageable. This also suggested by literatures that suggested that cloud computing gives adopters two main advantages over: First, it prevents them from spending high up-front costs on IT resources that may not be fully utilized in the future, Second, it allows them to face occasional spikes by flexibly adding more resources at any time when needed.

4.1.4 External Factors

The following topic will present the different prerequisite that should be considered for this study which includes the ability of cloud computing provider's services such as (IaaS, PaaS and SaaS) and supports accordingly, the ability to meet high security trust and privacy, meet standards and commitment for SLA for banks. By suggesting what type of cloud model (Private, Public, Hybrid, and Community). Availability of data communication from one provider to another provider in terms of time and resource, latency issues, and switching cost. On the other side the availability of legal frame works, the maturity of national IT infrastructure, competitive pressure and government support which can affect the adoption of technological innovation in Ethiopian banking industry also analyzed in this study.

4.1.4.1 IT Infrastructure

The overall IT infrastructure in Ethiopia is recently improving and it creates the opportunity for many industries including banks to be networked and digitized their systems rapidly. Thus the banks started to use ATM, Mobile, Internet, POS machines. Studies show that the level of maturity in telecommunication infrastructure is one of the basic elements in the adoption of cloud computing [42]. Still many of respondents complained about the usual inconsistency of the IT infrastructure for the customers to efficiently use E-Banking. On the other hand some interviewee agreed that the current government mainly Ethio telecom effort on improvement of national infrastructure, it will encourage banks to adopt different technological innovation.

Therefore, one of the major problem for adopting external cloud providers resources and support identified in this study is the current maturity level of IT infrastructure which might create latency problems for transferring data to and from the cloud stakeholder.

4.1.4.2 Competition between banks

The other major element that is depicted on different cloud computing literatures; competitive pressure is considered as driver for the adoption of cloud computing in developed country.

Respondents from some of the banks IT leaders agreed with the idea that the current competitive pressure among newer and older banks in Ethiopian banking sectors is considered as factors for the rapid growth of using innovative technologies. Also some researches indicates that

cloud computing can help to increase the pace of innovation, specifically for emerging market banks by allocating them to deploy new products quickly and at low cost which allows them to compete more effectively with matured banks whose deployment process in enterprise datacenter can be significantly longer [43].

The respondents from national bank confirms that, the central bank enforces and encourages the banks to work collaboratively by integrating their services to improve the speed and efficiency of banking market in Ethiopia.

4.1.4.3 Legal and Regulatory aspects

Internet, mobile, national Electronic payments systems, and agent banking system currently looked up in Ethiopian legal system, but it is does not include how cloud computing model support E-banking systems. This kind of legal framework inspires and enhances the introduction of modern banking system such as ATMs, credit and debit cards, mobile, POS, internet banking and interoperability between each other. All interviewees agreed that there is no specific legal frame works in Ethiopia from the government and also internally to adopt and implement cloud computing. Likewise, respondents agreed that the differences on banking regulation in different country will have impact on the adoption of new technological innovation such as cloud computing. Similarly, the respondents from NBE stated that there is no legal framework associated with cloud computing yet.

ITU has focused on regional approaches to governance in cloud computing and identified ways for organizations to respond to contemporary governance requirements. Key factors include good relations and more open channels of communication between all cloud computing players and the regulators [44].

Researchers suggests that without these laws in place and an assurance that surveillance of networks is limited to cyber defense and law enforcement investigations, the ability for businesses to engage in a service that puts their data and business at risk is limited [44].

4.1.4.4. Mobile and Agent Banking Services regulation in Ethiopia

In 2012, NBE established a clear set regulation on the use of mobile and agent banking. It encourages them to focus on technological advancement competition between the banks.

The National Bank of Ethiopia is responsible for ensuring that financial institutions are delivering mobile and agent banking services without compromising the safety and trustworthiness of the financial system of the country. In this thesis I review NBE, No. FIS /01/2012 directives as follows:

Modes of Business Conduct

Only financial institutions that are licensed by the National Bank are allowed to engage in mobile banking services. Mobile and agent banking service should be carried out only in Ethiopia using only Birr as a currency. Financial institutions can carry out mobile banking through their agents by making sure fully responsible and liable for all actions and omissions of its agent.

All transactions involving deposit, withdrawal, payment or transfer of cash from or to an account shall be made on real time basis and financial institutions shall ensure that agents are able to carry out real time transactions.

Limits of Mobile Transaction

The maximum balance that should be available in a mobile account of a person with a financial institution at any times shouldn't exceed Birr 25,000.

Daily mobile banking transaction that involves debiting of an account by a person with a financial institution shall not exceed Birr 6,000.

It also includes;

- Application Processing and Approval
- System Technology

- Customer Due Diligence Requirements
- Agent Management
- Agent Contract
- Agent Due Diligence
- Agent Contract Termination
- Relocation, Transfer and Closure of Agent Premises
- Customer Protection
- Reporting Requirement

4.2 Suggesting the cloud environment

All Ethiopian Banks are large scale organizations country wise, where they are having several processes which are undertaken and dispatched by themselves. Currently they keep both core and non-core application at their datacenter, because of this the maintenance time and cost issues are increasing through time. In order to overcome this they can use hybrid cloud, where they can keep the core banking in private cloud and non- core application in community cloud. Hybrid cloud is having more functionality with better performance compared to other cloud environment also by the integration of private and public cloud it is more secured. Hybrid Cloud computing cost is also affordable for computing the whole environment. Cloud-based services can be provided by IT companies which have large datacenters and huge software infrastructures with skilled manpower who can run the datacenter. Such cloud service providers are Amazon, IBM, Google, Azure, etc., which provide various IT services such as IaaS, PaaS and SaaS to consumers [44]. Virtually customers can deploy and run their data, applications, services on the providers IT infrastructures without the need to invest on IT infrastructures, and billed by providers as per the use of the infrastructure. This might decrease upfront investment on infrastructure cost and its management complexities to enterprises. Though, the result shows that banks would not be willing to put their core applications on the external public clouds because of fear of risks on customer data privacy, security and confidentiality issues that might be brought from using it.

Besides, the NBE directives covered in the national payment system and mobile and agent banking services limits the third party IT service provider to those only working in Ethiopia. Since processing financial data abroad the country is a difficult issue because of these regulation and

various concerns of security risks brings from using external public cloud service providers. The fact that customer records and data must be secure and confidential, thus, banks need to protect their customer's records against any anticipated threats or risks as well as unauthorized access that could cause substantial harm or inconvenience to the affected customer.

The current general infrastructure especially telecommunication infrastructure in Ethiopia would create latency problems for deploying and running the banking system on the public cloud. All respondents stated that high bandwidth internet is required because it is considered as a base for providing cloud computing services. The above mentioned requirement must be full filled for implementation of cloud computing to be possible in Ethiopian banks.

One of the interview questions was to suggest cloud environment if they have to choose to use cloud computing in the future. The interview was conducted keeping informed the interviewees about the objective of this thesis. Apparently all the respondents were equipped with the concept of cloud computing such as its service and deployment and delivery model.

According to the interview and literature review, Hybrid cloud is been selected because of the flexibility of services, use of internal and external resources and security large scale organizations because they can use both internal and external resources, they also provide some of the cloud services to different organizations and can afford for less cost.

I suggest the cloud environments by matching the results of interview and literature review from the requirements (security, flexibility, functionality, cost and performance) given by banks; this is explained in table 4.1.

Requirements assessed from banks	Suggestion of Cloud Environment	
	INTERVIEW STUDY	**Literature review**
Security	Security is one of the factors to be considered for Ethiopian banks; needs high security for their data and applications to be processed within the organization. So, hybrid cloud is more secured when compared to public and private clouds, because they can have the core Application within their organization and Non-core outside their premises according to the interviewee prefer hybrid cloud because of the security.	According to the literature review many researchers suggested hybrid cloud for banks based on the following Requirements - High Security - High Performance - Greater Flexibility - Better Functionality
Cost	Cost is one of the factors to be considered for banks; because it is measured based on the use of services in hybrid cloud environments, which provides affordable cost to the banks.	
Functionality	Hybrid cloud provides greater functionality when compared to public and private cloud. Where they can outsource the non- core application Like E-mail, Travel, Payroll, Conferencing, Social media and in house functions like ERP, Finance, Human Resource..	

Flexibility	Flexibility is one of the factors to be considered for banks in Ethiopia; where hybrid cloud is more flexible than other cloud because they can add/change/update core and non-core services according to the use of organizations.	
Performance	By using hybrid cloud, both internal and external resources are used where the organizations are having sensitive information in one system and non-sensitive information in another system. So it makes the system to have high performance.	
Ethiopian banks can also use community cloud for sharing infrastructure and systems like Check Truncation system that required national bank involvement and ETSwitch payment system that all ATM, and POS from all banks can make transaction throughout the country at all machines. They can all share the expense and it is less expensive than a private cloud, and works much like a public cloud, except that it is restricted to only members of the community. Community cloud is also mostly used only by the large organizations like government, educational institutions, and non-profit organization [45]. Hereby Ethiopian banks can also share their infrastructure and use internal and external resources.		

Table 4.1 comparing the assessment made with the interview study

Based on the prospect of its usability, I suggest Hybrid cloud environment for Ethiopian banks. During the literature study, I described about all the cloud environments and now in the following point showed how the inputs such as High Performance, High security, Affordable cost, greater flexibility and more functionality for Ethiopian banks is used in this work from literature review and interview.

- A hybrid cloud is composed of online storage reliable, secure place to store data, online anywhere and whenever we can connect to the Internet and web based applications will be possible in this way it is possible to free up resources and processing power.

- By the use of community cloud services along with their private cloud services hybrid cloud makes the customers to decide a feasible and cost- saving methodology .

- Here the data is been secured in hybrid cloud architecture, that consists of private clouds for core applications such as the core banking, non-core application will use community clouds for information gathering, dissemination of public information.

- IT departments should focus on strategic ideas that add value and create competitive advantage, rather than getting delayed in the daily information of managing servers by outsourcing IT infrastructure. This will achieve greater performance while outsourcing the services.

- The hybrid cloud exploits flexibility in the organization, as it can be a composition and combination of at least one private cloud and at least one community cloud.

The non-core applications such that email, procurement, human resource system, etc. services and data that will be used by the general public and different users will be placed on community cloud. In private cloud, the core applications, data, customer's information will be stored and accessed securely with the users of the organization. Because, the private cloud environment is created by the organization itself, by different services, application and data. Hybrid cloud can be a mix of both private and community cloud environments. The data it is more secured in this environment than using public cloud. The data in this private environment will be used and accessed only by the users of the organization.

CHAPTER 5

PROPOSED MODEL

In this chapter I will describe the requirements and the design of a cloud environment that can be suitable for Ethiopian banks. This model is designed in hybrid using private cloud and community environments which are used for sharing the infrastructure like network, storage, servers and more resources for banks and with security requirements which are explained in the coming sections. Also each block of this model is explained in the following sub-sections.

5.1 Inputs for designing the new cloud model

In this section I designed a hybrid cloud model that consists private and community cloud model by considering the interview that was held with IT authorities and literature review. I have designed a hybrid cloud model environment by considering the following security requirements.

Inputs from Ethiopian banks

The following requirements should be considered depending on how core (sensitive) and non-core (non-sensitive) information there will be. Ethiopian banks should separate the network for each security level and these levels are:

- Public information (Secret/Restricted, Secret/confidential)

- Internal information (Secret)

- Private information (Secret/Top Secret)

These requirements is based on how sensitive the information is like core banking application and databases. Internal information's like HR systems, internal communication systems etc. The other is more public information like the banks website social Medias etc.

Inputs from Literature Study

- Building internal firewall, by ensuring the security inside the organization.

- Maintaining different servers for different applications (Mail server, Web server, Network server, SSL-VPN server, etc.)

- Secure web filtering

- VPN tunnels for connecting to a private local area network at remote location

- Community and Private cloud environments.

5.2 Designing the model

Cloud Computing is specially known for its fast internet collaboration condition [46]. Here I propose a model (see figure 5.1 every time each user try to connect to the system of the cloud they should be connected to the system via an Asymmetric SSL Tunnels (AST) which passes through the Secure Socket Layer VPN (SSL VPN) server. In earlier client server architecture model users were connected through Ethio telecom VPN tunnel for security purpose.

Some researchers suggested that there is a popular form of security model by having Cloud firewall inside the cloud model [47], this provides the information of how and where the firewall works and to be installed in the system. In general there is a problem with the data that are encrypted at one end and decrypted at the other end, or contrariwise for the reverse direction. All the data flows of VPN are relayed by VPN server via SSL tunnels, those symmetric SSL tunnels cause a lot of computational load concentrated in VPN server, and make it the bottleneck of VPN [48]. VPNs and AST have been used In order to overcome that bottleneck for larger scale SSL. Here I present the proposed model along with its building blocks as follows:

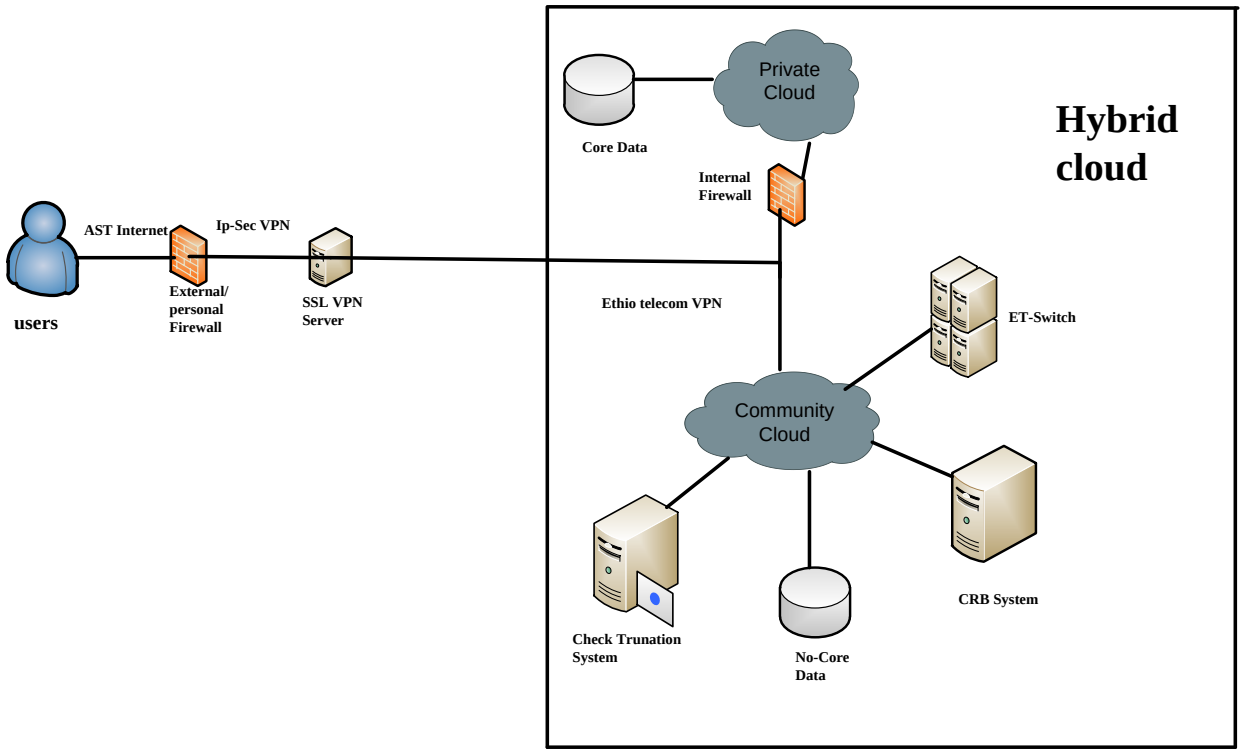

Figure 5.1: proposed cloud model

i) User

Banks employee and customers are the users of this system, where they can operate with this cloud network from any of their branches and cell phones by Asymmetric SSL Tunnel (AST) through Ethio telecom VPN or internet, this feature provides a safe and secure access to the user.

ii) Internal Firewall

A single firewall at the Internet gateway is no longer sufficient. In some cases if I want to build an internal firewall; it is better to have firewall between two separate organizations that share a network, rather than between a single organization and the Internet. In this context the internal firewall differs from personal firewall [48]. This internal firewall is maintained inside each bank.

iii) SSL VPN server

Generally computer networks use a tunneling protocol when they go through an un-trusted network that protocol provides a secure path. Secure Sockets Layer (SSL) is presented in the transport layer of Open Systems Interconnection model (OSI) model, where this cryptographic

protocol provides communication security over internet. SSL VPN is a secure remote access solution based on SSL/TLS [49] protocol. According to the prediction of Gartner Company [50], SSL VPN market will grow more than 170% per year. Compared with other virtual private network technologies, SSL VPN has the following outstanding advantages: low cost, easy-to- deploy, fine-grained access control, etc. But its performance and scalability are also hampered by the computation overhead of SSL protocol. VPN server is the key equipment to construct an asymmetric SSL VPN.

iv) Personal Firewall

A personal firewall is defined as a software service running in an operating system like Kaspersky, Symantec, AVG etc. that provides simple firewall capability for a personal computer. Most personal firewalls support static packet filters.

It would be better if all users should use a personal firewall on their systems, not only to help/prevent others at nearby hotspots from accessing their devices, but also as part of a broad-based defense against hackers residing on other parts of the Internet.

v) Private Cloud

A private cloud is one in which the services and infrastructure are maintained on a private network. For the sec of great level of security and control. The organizations require purchasing all software, platform and infrastructure. It has an impact on cost but in this case it is a financial institution, so it should maintain the security and control of each of the organizations sensitive core banking data instead of outsourcing to other providers.

vi) Hybrid Cloud

A hybrid cloud includes a variety of public and private options with multiple providers. I have to keep track of multiple different security platforms and ensure that all aspects of business can communicate with each other. Hybrid clouds can be used for the organizations to use a SaaS application but is concerned about security. The sharing can be like general information of the organization, messaging and other applications. And company offers services that are tailored for different vertical markets. You can use a community cloud to interact with the clients but keep their data secured within a private cloud.

vii) Community cloud

Ethiopian banks can use community cloud for non-core applications such that mail/exchange, web server, human resource system etc. It is used also doing collaboration project and workload for applications that is used by lots of people.

Community cloud can also be implemented where several organizations have similar requirements and where they can share the infrastructure. For the services that needs NBE involvement like CRB, Check Truncation System, ET-swich etc. that can use a SaaS application but is concerned about security. In this model, community cloud is used for sharing the information with employees of the banks, accessing applications, and sharing infrastructure. Here the computing cost of community cloud is more than the public cloud, but it offers of higher level of privacy and security.

viii) Storage/databases

Here in this architecture it kept two different databases. One DB is to store the core/sensitive information from the private cloud and other DB to maintain the non-sensitive information from the public cloud. The hybrid storage cloud uses a combination of public and private storage clouds; they are often used for archiving, backup functions and allowing local data to be replicated to a public cloud.

ix) Asymmetric SSL Tunnel (AST)

Secure socket layer based virtual private network (SSL VPN) provides a safe and easy approach for remote accessing. SSL provides CIA (Confidentiality, Integrity, Availability), also provides permission to be used with any protocol that uses TCP as the transport layer. Symmetric SSL tunnels cause a lot of computational load concentrated in VPN server, and make it the bottleneck of VPN [51].

To overcome this bottleneck SSL VPNs overhead that is caused by symmetric VPN Asymmetric SSL Tunnels came to help. Where AST computational load is distributed to detached internal application servers. AST solution improves the overall VPN throughput radically and this solution doesn't need any modification on internal server programs [52]. This model uses two firewalls one is maintained inside and other is maintained outside the organization.

Personal firewalls support static packet filters. This static packet filter provides network packet filtering based only on packet information in the current packet and administrator rules. Static packet filtering filters packets are based on [53]:

- Administrator defined rules governing allowed ports and IP addresses at the network and transport layers of the OSI network model.
- Packet contents including the network and transport layer contents

So by these two firewalls I can run the model effectively and efficiently. I did not depend on only on firewalls, for communication purpose we can use SSL VPN server. SSL provides CIA (Confidentiality, Integrity, Availability), also provides permission to be used with any protocol that uses TCP as the transport layer. This cryptographic protocol provides communication security over internet.

From the literature review researchers advises that the following security requirement also should be look after when proposing the model [54]:

1. IP-Sec VPN

2. Network intrusion prevention system

3. Secure web filtering

IP-Sec VPN

This network protocol supports encryption and authentication and it is located in the network layer of the OSI model. IP-Sec is frequently used in so-called "tunnel mode" with a Virtual Private Network (VPN). However, IP-Sec also supports a "transport mode" for direct connection between two computers. This IP-Sec VPN can be a part of the proposed model in addition to Ethio Telecom VPN for strengthen security.

Network intrusion prevention and detection system

This Intrusion Prevention system (IPS) is a network security control that monitors system and network from the malicious activity. This system is also called as Intrusion Detection and prevention System (IDPS). This intrusion detection system can be hardware/software application that monitors all network system activities. It should be placed at the client side of the model.

Secure web filtering

Secure web filtering is very important for all the organization especially for financial institution to consider the following steps in order to be safe from the attacker. First the IT concerned organ need to lookout against the security risks and bandwidth drains of unrestricted access to all the sites, illegal file downloads, or visits to sites where PCs and networks can be exposed to viruses and malicious software. There is a product called Smart Filter, which meets all the requirement of the organization also its simple to manage, highly inexpensive and easy to use. This web filter will be placed after the internal firewall in the designed model, this requirement is been used in order to block the malicious web sites, file types, MIME (Multipurpose Internet Mail Extensions) types and blocking pages from IP, allow only hosts.

5.3 Analysis of designed model

The existing system of the Ethiopian banks is the traditional client server architecture. It means they typically host their own network infrastructure, their own private servers and the like. After gathering the general information from the banks I started literature review and did an interview regarding the improvement of existing system and how could we overcome the problem of the current system.

Most of the experts gave similar answers about the problem in using client server architecture, since it is hosted on sight, the organization needs to provide adequate power, cooling, and maintenance. And the organization needs to invest a lot for purchasing hardware along with its necessary gadgets every time there is a need.

The current system also requires system, network, database, and datacenter administrators. With these pre-requirements, I have designed a new model that can be used by Ethiopian banks with the combination of public and private cloud. This means that I suggest the hybrid cloud environment with the use of community cloud where they can also share their infrastructure with the other banks. This gives Ethiopian banks more comfort and the model is easy to use. For connecting to the cloud, I designed the cloud with AST connectivity. This asymmetric SSL Tunnel,

- Avoids from the bottleneck that can be arise from symmetric VPNs and provides a safe and easy approach for remote accessing by using AST.

- Provides a secure path through an un-trusted network.

It is necessary to launch a VPN tunnel, if the user wants to access data from the community cloud.

After connecting to the cloud, a user gets the permission to share the infrastructure (Mail servers, web servers, HR Systems, Supply chain management and etc.) via Hybrid cloud. According to the interview results many suggestion goes to hybrid cloud, which is a combination of Private and Community cloud. The main reason for shifting to hybrid cloud is security and ability of using software and saved files with different servers. All the sensitive/core information/data is stored on private cloud and non-sensitive/non-core information is stored on community cloud. Therefore, by using this model Ethiopian banks can improve their services.

5.4 Suggestion given by Ethiopian Banks

Many interviewees from the selected banks appreciate the relevance of the proposed cloud model. Data privacy and security regulations in Ethiopia (according to NBE) prohibit the storage and processing of customer data outside Ethiopian borders.

Banks are also suspicious of the potentially disastrous impact of a serious breach of security and privacy, or of even a brief outage in areas such as ATM operations, fraud monitoring or debt card processing. To comply with the rules which prohibit customer data to be passed beyond national borders and the fear of risks, the options of local cloud service provider for community cloud is considered in this study and have positive feedback from respondents.

The model has been designed in the suggested cloud environments with the suggestion of Ethiopian banks IT decision makers and from literature. Interoperability and scalability comprise all features regarding the maximal number of available resources which can be used simultaneously from the cloud system. This capability of the system allows easy data and service integration between banks and provider.

In the proposed model all banks IT infrastructures can be virtualized using internet or Ethio telecom VPN connection, then using the platform data and applications can be integrated and made available to end users. In this situation, Platform and infrastructure security focuses on the communication protection via secure cryptographic protocols using AST Tunnels and dedicated

firewall settings. While channel and business protection includes the access management and role concept related to the used services.

The proposed model supports the data privacy requirements of the banks through the techniques of data encryption and they know the physical location of the datacenter on a private cloud. The respondents agreed that using community cloud for some services that involve NBE will have a great advantage for minimizing upfront as well as maintenance cost. These capabilities of cloud computing helps banks to reduce the cost by sharing it to all banks because infrastructure is rented, not purchased, the cost is controlled, and the capital investment can be zero. Also applications are developed more by assembly than programing.

Moreover, Hybrid cloud computing can help to increase the pace of innovation, specifically for emerging market banks by allocating them to deploy new products quickly and at low cost which allows them to compete more effectively and efficiently that deployment processes can significantly longer time more space and more system administrators to maintain it. The use of well-understood technologies such as data encryption, IP sec VPNs, AST Tunneling, which are included in the proposed model. This meets the concern of security raised by banks whether the cloud environment can be made as secure as that of the current situations.

From the business perspective Cloud computing improves easy collaboration between banks in which customers of the integrated bank` can interact with the shared system in a more engaging way than before. Customers' ability to access the banking services by using all the channels such as mobiles and internet are improved, the employees of the banks will have improved job satisfaction. Moreover, this cloud model can actually reduce repeated IT investments and also for the banks IT leaders it will free them from routine work and it allows them to focus on their vision.

CHAPTER 6

Conclusion and Recommendation

6.1 Conclusion

In this thesis, I did a thorough study on different definitions of cloud computing, cloud environments and cloud services. The main goal of this thesis is to propose a suitable cloud environment from public, private, hybrid and community clouds to Ethiopian banks. To do this an interview has been carried out from selected banks. From an analysis of the results of the empirical study, most of the organizations prefer private and hybrid cloud. This is because they are all financial institutions and our country's regulation of customer's data cannot be held by outsiders outside the country for security reasons. Hybrid clouds can be used by large organizations like banks which can use both internal and external resources in a secured way.

Big financial organization like banks have both internal, external resources and different channels of communications, both private and community cloud environments are proposed and also they can implement for their future use. This allow the banks to be flexible, high performance, less cost and secured. Ethiopian banks have similar requirement that involve NBE for some services like ETswitch, CRB system, and Check Truncation systems, therefore I also suggest community cloud because it allow them to share cost and IT infrastructure.

The research shows that hybrid cloud computing model would be the main form of cloud adoption for Ethiopian Banking Sectors. The proposed hybrid cloud provides a benefit for unified banks IT infrastructure with the proposed cloud model depending on the sensitivity of banks data and applications in each process, and the degree of business innovation and differentiation. By integrating traditional IT and private cloud-based services with the new local cloud service provider, this hybrid approach protects current investments in Ethiopian banks.

From an analysis of the results of the literature review and interview study, the hybrid cloud environment is more preferable considering the following factors:

- Cost – Hybrid cloud is cost effective and depends upon the computing and use of internal/external resources,

- Security – Although the services are provided from different cloud provider for private and community cloud, security can be maintained inside the organizations for private cloud by taking the Service Level Agreement (SLA) from cloud provider,
- Performance and Functionality – it depend upon the applications and services used by the organization,
- Flexibility - by outsourcing the infrastructure it enables IT departments to focus on strategic ideas that add value and create competitive advantage, rather than getting on routine work in the daily information of managing servers. As a result this provides greater flexibility while outsourcing the services.

I proposed a model to Ethiopian banks for improving and making better changes of their existing system. This model is designed by making a literature study, and interviews with the IT leaders/experts in the banks. The model has been designed in the suggested Hybrid and Community cloud environment which can overcome the issues of Ethiopian banks from using traditional client-server infrastructure.

6.2 Answering the research questions

In this section, I provided the results for the research questions that has been asked in chapter one.

RQ 1: Which environment (public cloud, private cloud and hybrid cloud) could be suitable to Ethiopian banks with respect to performance, security, cost, flexibility and functionality?

- After completing the literature study, I conducted an interview. The literature study tells how the hybrid cloud makes the organization to keep safe of both sensitive and non-sensitive data.

- The information shared can be like general information of the organization, messaging and other applications. Since the hybrid cloud medium security offer banks can use this for non-core applications. Community cloud is affordable because the infrastructure is shared with all the banks that uses this environment for the shared systems that involve NBE involvement. Besides it offers higher level of privacy and security.

- From the interview study I found that:

- Public cloud could be useful for small scale organizations that don't have the required material and human resource needed to use cloud computing, so that they can outsource the infrastructure in which, it could be cost effective and maintained by the service provider. This also provides with greater functionality and flexibility

- Private cloud could be useful for large organizations like banks, where the infrastructure can be used by more users and it can be maintained and managed by organization itself. This also provides greater security, reduction in cost and good performance.

- Some of the organizations are willing to shift to hybrid cloud environment in future, depending upon the size of applications in which they use. The companies specified that, hybrid cloud environment can be used for the organizations using external resources and for large scale organizations.

RQ 2: How the services Infrastructure-as-a-Service (IaaS), Software-as-a-Service (SaaS),

Platform- as-a-Service (Paas) could be used by Ethiopian banks?

- The second research question RQ2, is focused on the cloud services such as IaaS, SaaS and PaaS. In this research, a detailed study has been carried out about cloud services, different cloud service providers and their features. As a conclusion, there is a possibility for Ethiopian banks to outsource some of the service to the cloud providers like Microsoft Azure, Amazon Web Services and to other providers specified during this research.
- The hybrid cloud environment in an organization provides more benefits of using IaaS, SaaS and PaaS. If the services are outsourced from different cloud provider, Etiopian banks should have an agreement for maintaining the security for data, servers and applications from inside each banks. As they have similar requirement for all banks

that involve NBE using community cloud will play vital role for sharing cost and infrastructure.

- All Ethiopian banks currently uses Client-server architecture, in this thesis I proposed hybrid consisting private and community cloud environment which provides High Security, High Performance, Greater Flexibility and Better Functionality. This combination of private and community cloud environment can be applied to pilot bank at first and by improving the requirements from the pilot bank it could be implemented to all banks by modifying the model.

6.3. Recommendation

Even though the results of this study are promising, further work should be done and prepare a framework and roadmap for successful implementation of the proposed cloud model. The model should be observed carefully by the banks IT leaders and cloud Provider's IT experts to mitigate the current issue of Ethiopian banks.

Although, cloud computing implementation for organizations including banks in the developed countries is highly favored in recent years. But in developing countries like ethiopia it is hard to find companies that uses cloud computing. Cloud computing literature is still in its early stages. The scope of current literature that is focused on cloud computing in developing counties can be considered as shallow and thereby future research should consider cloud computing from less charted and novel perspectives. As this study shown, cloud computing paradigm has still many aspects that should be understood better before it comes to the mainstream of IT enterprises. Some future research directions are presented as follows.

- Future studies can explore business models of cloud computing services. Researchers will evaluate the different cloud business models and their differences according to business model. In particular, it should be analyzed what different capabilities different business models require from the services provider.

- By ensuring cloud computing's viability from services provider view point, exploring the changes in risk sharing model between services provider and banks`/other customer that cloud computing paradigm necessarily imposes.
- Developing framework`s for banks or other types of institutes on enhancing the security architecture of virtual Data centers in Cloud Environment. Researchers might focus on providing security in cloud that protects the data in the Cloud Environment.
- Researchers might focus on an analysis of costs and return of investment in a large financial institution that has transitioned to Cloud.
- A detailed overview of the software and hardware that are part of the proposed Cloud packages including adaptation with legacy core banking system.

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Appendix

Interview Questions:

1) What are the ICT services and supports that are provided for internal and external users of the bank by your office?

A. For internal users, employees and managers?

B. For external users, customers, partners and suppliers?

2) Do you think these services are enough to achieve your mission and vision, in improving quality service to customers, reducing cost and IT complexity, optimizing ICT usage efficiently, dynamic scalability of resources, increasing competitive advantage and modernizing your company?

3) Is there any constraint in providing an efficient ICT services?

4) What are the feedbacks of the users about your ICT service? Positive and negative

5) What is the yearly budget for the ICT department of the bank?

6) Does your bank have an ICT policy, based on country ICT policy and legal framework for new technology adoption? Do you know them?

7) What does cloud computing mean for you and, what are the main motives for cloud computing according to you?

8) Do you see any disadvantages or problems with implementing cloud computing?

9) As an Infrastructure director/ manager, VP,CIO what do you think is best strategy to provide ICT services for Banks to support with the current economic, business and legal context of Ethiopia?

10) If a cloud computing infrastructure/model is to be built in EBI that could be used by all banks in Ethiopia to provide ICT services, what will be your reaction to this strategy, what kind of services do you think your bank will benefit from the cloud-based technology?