**ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY**

**SCHOOL OF ELECTRICAL ENGINEERING & COMPUTING**

**DEPARTMENT OF COMPUTING**

A MASTER"S THESIS

ON

# A Cloud Based Architecture for Educational Resource Sharing In Ethiopian HEI

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE DEGREE OF

MASTER OF SCIENCE IN SOFTWARE ENGINEERING

**BY:**

Biniyam Wondie

February, 2017

Adama, Ethiopia

# Declaration

This thesis is my original work, and it has not been presented for a degree in any other university. All sources of materials used for the thesis have been acknowledged

_____

Biniyam Wondie

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

_____

Dr. Dereje Yohannes (Asst. Professor)

**February, 2017**

**ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY**

**SCHOOL OF ELECTRICAL ENGINEERING & COMPUTING**

**DEPARTMENT OF COMPUTING**

# A Cloud Based Architecture for Educational Resource Sharing in Ethiopian HEI

**By**

**Biniyam Wondie**

Names and Signature of Members of the Examining Board

| | | |
|---|---|---|
| Desta Zerihun (MSc) | _____ | _____ |
| Chair Person | Signature | Date |
| Dereje Yohannes (PhD) | _____ | _____ |
| Advisor | Signature | Date |
| Dereje Regassa (MSc) | _____ | _____ |
| Internal Examiner | Signature | Date |
| Dereje Teferi (PhD) | _____ | _____ |
| External Examiner | Signature | Date |
| Mohammed Kemal (MSc) | _____ | _____ |
| Department Head | Signature | Date |
| Dereje Regassa (MSc) | _____ | _____ |
| School Dean | Signature | Date |

## Acknowledgement

All praise and glory belongs to the Almighty God for the tremendous strength and courage. He gave me during my entire education endeavor. I have no words to thank Him enough for all His mercy, guidance and unlimited favors and blessings.

It is my pleasure and duty to acknowledge all supports, i.e., the many people without whom this journey could not have been completed.

Firstly, I want to acknowledge the insight, generosity, patience and encouragement of my advisor, Dr.Dereje Yohannes (Ass.professor), who helped me to keep up my hope to finish this work.

Finally, my grateful to all my family and friends for their continuous patience and support in helping me dedicate all my time to finish this work.

# Abstract

Cloud computing has becomes an adaptable technology in many organization .It represents an important changes in the way information technology is used. Moreover most of the education institutions in the world have become extremely reliant on IT. Universities can take the benefits of cloud based application provided by different services provider and facilitates their staff and students to perform various responsibilities. Using cloud computing, we can share educational resources anywhere, using internet enabled devices. The main aim of this research is to design a cloud based architecture to able to share educational resource in Ethiopian higher education institutions.

This study proposes Hybrid cloud platform architecture for sharing of educational resources in the Higher education institutions. The cloud based educational resource sharing architecture (CBERSA) adapts the IBM cloud reference architecture (IBMCRA) and NIST cloud reference architecture to exploit all considerations and features of cloud based software architecture. For the designed architecture a prototype system was implemented using Microsoft window azure platform. The prototype is very interactive and user friendly which have resource sharing and accessing portal. The developed prototype system was validated using 20 respondents in three higher education staff members and the result is presented in tabular, bar graph and pie chart form.



**Keywords**: Cloud computing, Cloud based architecture, Resource sharing, Software architecture, Higher Education Resource

# Table of Contents

# List of figure

# List of Table

# List of Abbreviations and Acronyms

**AAU: -** Addis Ababa University

**API: -** Application programming interface

**BSS**: - Business Support Services

**CC**: - Cloud Computing

**CCPM: -** Cloud Computing Platform Management

**CCRA: -** Cloud Computing Reference Architecture

**CCRM**: - Cloud Computing Reference Model

**CCRF: -** Cloud Computing Reference Framework

**CBAERS: -** Cloud Based Architecture for Educational Resource Sharing

**CDN: -** Content Delivery network

**CSP**: - Cloud Service Provider

**EHEIs**: - Ethiopian Higher Education Institutions

**EHEIHC**: - Ethiopian Higher Education Institutions Hybrid Cloud

**EthERNet: -** Ethiopian Educational Research and Network

**EUHC**: - Ethiopian University Hybrid Cloud

**EUPC: -** Ethiopian University Private Cloud

**GAE: -** Google Apps Engine

**HE:** Higher Education

**HEI:** Higher Education Institutions

**HERQA: -** Higher Education Relevance and Quality Agency

**IAAS: -** Infrastructure as a Service

**IBM**: - International Business Machine

**ICT: -** Information and Communication Technology

**IDE: -** Integrative Development Environment

**IIS: -** Internet Information Services

**IT**: - Information Technology

**JRE: -** Java Runtime Environment

**JSP: -** Java Server page

**MOE: -** Ministry Of Education

**MWA: -** Microsoft Window Azure

**MVC: -** Model View Controller

**NASA: -** National Aeronautics and Space Administration

**NIST**: - National Institute of Standards and Technology

**OSS**: - Operational Service Support

**PAAS: -** Platform as a Service

**PDA**: - Personal Digital Assistance

**QOS**: - Quality of Service

**RA**: - Reference Architecture

**RBAC**: - Role Based Access Control

**RDP: -** Remote Desktop Protocol

**REST**: - Representational State Transfer

**RF**: - Reference Framework

**RM: -** Reference Model

**SAAS**: - Software as a Service

**SDK: -** Software Development Kit

**SLA: -** Service level Agreement

**SOA: -** Service Oriented Architecture

**SOAP: -** Service Oriented Architecture programs

**SSH**: - Secure Shell

**S3:-** Simple Storage Service

**UML: -** Unified modeling language

**VLE: -** Virtual Learning Environment

# Chapter One: Introduction and Background

## 1.1. Introduction

Globalization, financial crisis, requirement of the students from the 21st century and other factors are leading to pressure on educational institutes in terms of ensuring appropriate IT (Information Technology) supports necessary for educational and research/development activities[1][2]. The institutions of higher education must address the students' requests with respect to IT and the access to institutional networks of wherever and whenever. Consequently, educational institutes recognize the need of adopting new technologies; new methods, instruments and learning techniques in order to satisfy the demand of the age[3] . New technologies have revolutionized education, yielding new learning delivery methods. E-learning extended the reach and support of education but relied on tethered computers, and hence was bound by location and time. Mobile learning (M-learning) extends E-learning by breaking these tethers, allowing learning to occur anytime and anywhere[4].

Now a day, education is becoming completely associated with the ICT on the content delivery, communication, storage, share and collaboration. But the use of Internet and Information and Communication Technologies (ICTs) to deliver educational resources is considered mainstream in the 21st century, yet in Higher Education (HE) in developing countries it is often seen as a luxury[5]. This has far reaching effects on teachers, learners and educational institutions in these countries, which often include a lack of basic ICT infrastructure and limited or no support for the training of teachers and learners in the use of digital online information sources.

In the past few years the concept of "Cloud Computing (CC)" has emerged as a viable and promising solution to the challenges associated with shrinking IT budgets and escalating IT needs. It has becomes a major points of interest in many fields. Cloud computing has also attracted educational with its potential for delivering economical, securable, reliable, and sharable education services. An increasing number of universities and educational institutions in the USA and UK are adopting cloud computing not only for increased cost savings, but also for improving the efficiency and convenience of educational services [6].

## 1.2. Background of the Study

In developing countries, universities are the main source of highly trained and skilled work forces. Therefore, teaching is often considered as the main activity in most universities[7]. Although, there are research oriented universities or specialized research institutions, their numbers are much smaller than teaching oriented universities[8]. In terms of teaching, a proper utilization and sufficient educational resources facilities are necessary for students. Overall, in both teaching and research, due to financial constraints in developing countries, resource investment is low. Addition to the financial issues, due to management priorities, educational resource investment is not well managed, leading to the lack of coordination in investment efforts and usage of rare resources. As a result, the resources are not well utilized, even though such resources are not enough.

To all these, academic resources are the main issues in teaching learning environment; so educational resources must be well utilized and properly manage. Beside these, research works and projects must be disseminate to the community and give a contribution to the community at the right time. So to make educational resources properly manage, properly utilize and to disseminate, we need advanced technologies which helps to store all educational resources at one center and enable them share and access educational resources everywhere, anytime .an emerging technology like cloud computing enables to do these. In recent years, the advent of Cloud Computing has excited an interest from different Organizations, institutions and users.

This is a result of the new economic model for the Information Technology (IT) department that Cloud Computing promises. The model promises a shift from an organization required to invest heavily for limited IT resources that are internally managed, to a model where the organization can buy or rent resources that are managed by a cloud provider, and pay per use.

Cloud computing has also attracted educational sectors with its potential for delivering economical, securable, reliable, and sharable education services. An increasing number of universities and educational institutions in the USA and UK are adopting cloud computing not only for increased cost savings, but also for improving the efficiency and convenience of educational services[9]. “Cloud Computing is a model for enabling ubiquitous, convenient, on-

demand network access to 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"[10].

## 1.3. Statement of the Problem

In today's technologically advanced world, education is a key instrument by which an individual and a nation can get the most out of what is good in the world[8]. And educating the youth is one important task of a government in building up a nation with competitive manpower that can shoulder the duties and responsibilities of the society in such a way that both individual, and national development, is ensured. To make all an educational resources must be properly utilize for the success of national development in building manpower. So to create a way for the success utilization and share of academic resources lends to fair delivery of educational resources and will produce a qualified competitive manpower among the institution.

In Ethiopia different initiatives are working as a parts of national capacity building. Among these, Ethiopian Educational and Research Network (EthERNet) as a part of national capacity building in higher educational institutions[11]. The Ethiopian Education and Research Network (EthERNet) was launched in 2001 to build and deliver highly interconnected and high performance networks for Universities and other Educational and Research Institutions in Ethiopia. More specifically, EthERNet was aimed to build and deliver high performance networking that connected these institutions with each other and similar institutions in the world, and by doing this to enable them to share educational resources and collaborate both within Ethiopia and globally. Since its establishment EthERNet has provided services for single institutions like datacenter, video conference, e-library and technical support. But EthERNet has not provided an educational resource share mechanism among the higher education ; since there is an integration problem in different technologies[11].Due to these, In Ethiopian higher education institutions there is no habit of educational resource sharing and collaboration and there is no online mechanism of accessing these services which makes easily collaborate and share; means still now in, higher education institutions there is a gap in collaborating and share educational resources among each other anywhere, anytime. These make the students, staff and HE community difficult to share academic resources with their peers, friends easily in each higher education institutions.

Hence the main problem is there is no advanced ways of educational resources sharing among higher education that enable them to share educational resources (teacher materials, course modules, course slides, articles, seminars, projects, etc.) and help to realize for fair delivery of teaching learning activity. This problem happen due to Lack of promote the sharing of information resources, Inefficient ICT administrative procedures and technical skill, Lack of assessing for teaching learning process ,Lack of communication and coordination among higher education institutions. So to handle the above problem the researcher proposed a cloud based architecture for educational resource sharing in higher education institution which makes them to share educational (Teachers materials, course modules, course slides ) resources and to disseminate project and research works. Hence, an attempt is to design a prototype of cloud based architecture for educational resources sharing.

The research will intend to get answers for the following research questions:

1. What are the current practices in resources sharing in HEIs?
2. What are the factors that prevent to share improve utilization of educational resources?
3. How could cloud computing offer support for proper utilization and share of educational resources?
4. How a highly available and accessible cloud based application design for educational resource sharing?
5. How can cloud computing enhance the learning experience?

## 1.4. Purpose of the Study

The purpose this paper is to present a prototype architecture that may enable educational resources sharing and collaboration in higher education institutions, using the latest advancements of cloud computing technology to foster a culture of research, collaboration and resource sharing. All the higher educational related resources can be accessed via internet enabled devices. Using this, we can reduce resource sharing time and cost. Generally, the purpose of this study is:

- To be able to share and access educational resources anywhere for students, teachers and academic staff.
- To tap the combined power of shared educational resources so that higher education institutions community in the country becomes more conducive by exchanging and accessing educational resources everywhere, anytime.
- To synthesis the strategies and requirements of cloud computing architectures in higher education institutes.
- To design a cloud computing architecture for resources sharing in accordance with the higher education institutions framework.
- To realize build and sharing of the digital resources, So as to improve resource sharing habit.
- To evaluate a cloud based architecture in accordance with the Ethiopian higher education research and network ICT initiatives.

## 1.5. The Objectives of the Study

### 1.5.1. General Objective

The general objective of the study is to design a cloud based architecture for Ethiopian higher education institutions to enable them to collaborate and share educational resource.

### 1.5.2. Specific Objective

- To conduct survey of higher education institutions collaboration in academic resources.
- Identify factors of educational resources sharing in higher education institutions.
- To identify whether Ethiopian HEI is aware of the potential that Cloud Computing might present to its operations.
- To examine the necessity of Cloud Computing for educational resource sharing.
- To identify best cloud computing platform for HEI educational resource sharing.
- To design the proposed cloud based architecture.
- To develop and test the prototype system for the validation of the proposed architecture

## 1.6. Scope and Limitation of the Study

### 1.6.1 Scope of the Study

The main intent of the study is to design educational resource sharing architecture based on cloud computing which is only for Ethiopian public higher educational institutions. For the designed architecture, a web based prototype system have been developed which were tested on public cloud platform and it would not have full implementation; because it needs more time, budget and human power. In the developed architecture, we can share educational documents only; multimedia educational resources didn't consider in the developed architecture: due to the integration of the selected platform service with other cloud computing services and it needs more time. Moreover, taking time, cost and access constraints into consideration, the study examined three public HEIs (Addis Ababa University, Adama Science and Technology University and Assosa University). The population of the study consists of academic and administrative staff whose concern in IT and cloud computing professionals.

### 1.6.2. Limitation of the Study

The challenging limitations of this study were the difficulty to get timely responses to the interviews and questionnaires. The awareness of cloud computing skill in the institutions was also the limitation of the study and lack of educational or academic resources sharing literature on previous and current technology practices.

Moreover, implementation of the prototype system on hybrid cloud, evaluating the performance and efficiency of the architecture online by creating virtual machines also the limitation of the study.

## 1.7. Significance of the Study

This study is significant because it adds both theoretical and practical knowledge to the available literature of cloud computing in education sectors in HEIs.The study will believe to bridge the research gap in the area of educational resource sharing in HEIs in the Ethiopian context. This research will allow the Ethiopian Higher Education Institutions to consider alternative ways of educational resource sharing for proper and efficient utilization of academic resources, convenient access and realization of fair teaching learning process.

The direct beneficiaries and indirect benefits of the result is listed below**.**

**Benefits for Higher Education institutions:**

- The higher education institution has the opportunity to collaborate and share educational resource over time ubiquitously.
- It will used as initiatives to develop and implement educational based application and to provide supportive supervision to the ICT staff throughout the organizations.
- It makes the resource sharing cost effective, interactive and deliverable for the higher education institutions and it leads to sustainable ability to solve problems, to implement changes and to build effective action to reduce inaccessibility of higher education resources.

**Benefits for Students:**

- Enables mobilization of educational resources. Students in the higher education institutions will access the educational materials anytime anywhere using their mobile phone, tablets PDAs, PCs and other internet enabled electronic devices.
- Used to create higher education learning environment in which the learners in the world shares their experience and knowledge for others in the education and for the community.
- It provides multiple modes of resource collaboration and share with the help of current technology.

**Benefits for ministry of Education:**

- It creates the opportunities to develop electronic or web based educational materials and resource for educational institutions.
- For the funding and partner organization, it will be used to show the higher education institutions technological status.

**Benefits for educational providers and for Researchers:**

- It can be used for constantly monitoring the educational initiatives to make a decision to advance or rework initiatives by the decision makers in the education area.
- It will be used to identify and promote good practice by sharing academic resources experience from other higher education providers.
- Researchers from educational sector and software engineering fields can use the result of this thesis as an input to their study.

- It will also help them to design a better architecture based on new technologies like by integrating cloud computing with SOA and web services together with other educational technologies.

## 1.8. Organization of the thesis

This thesis is organized into seven chapters: the first Chapter briefly discusses about the introduction part of the study, background of the study, statement of the problem, purpose of the study, the general and specific objectives of the study, the scope and limitation and significance of the research. Chapter two gives an overview of literature review and related research works. Chapter three methodologies. Chapter four focuses on Platform selection and designing the proposed architecture. Chapter five prototype implementation. Testing and evaluation of the system by domain area is discussed in the six chapter and finally chapter seven gives final conclusions of the research done and forward recommendations for future studies.

# Chapter Two: Literature Review and Related Works

## 2.1. Literature Review

### 2.1.1. Cloud Computing

The information technology industry has required standardizing the definition of Cloud Computing. One of the first standardized definitions is the one by Forrester Research, Inc.[12][13]; in which they defined Cloud Computing as "A standardized IT capability (services, software, infrastructure) delivered via Internet technologies in a pay-per-use, self-service way"[10].

The most recent and accepted standardized definition of Cloud Computing is the one by the National Institute of Standards and Technology (NIST)[13][14]. The NIST definition is relatively technical, and covers all of the cloud service (IaaS, PaaS, and SaaS) and deployment (public, private, hybrid, and community) models, as shown in figure 2.1. The NIST definition is concise, accurate, and distinguishes between characteristics and enabling technologies (i.e., virtualization), and between main and derived characteristics (rapid elasticity vs. massive scalability); nevertheless, the definition ignores the business model of Cloud Computing, which is the main driver for moving to the cloud.

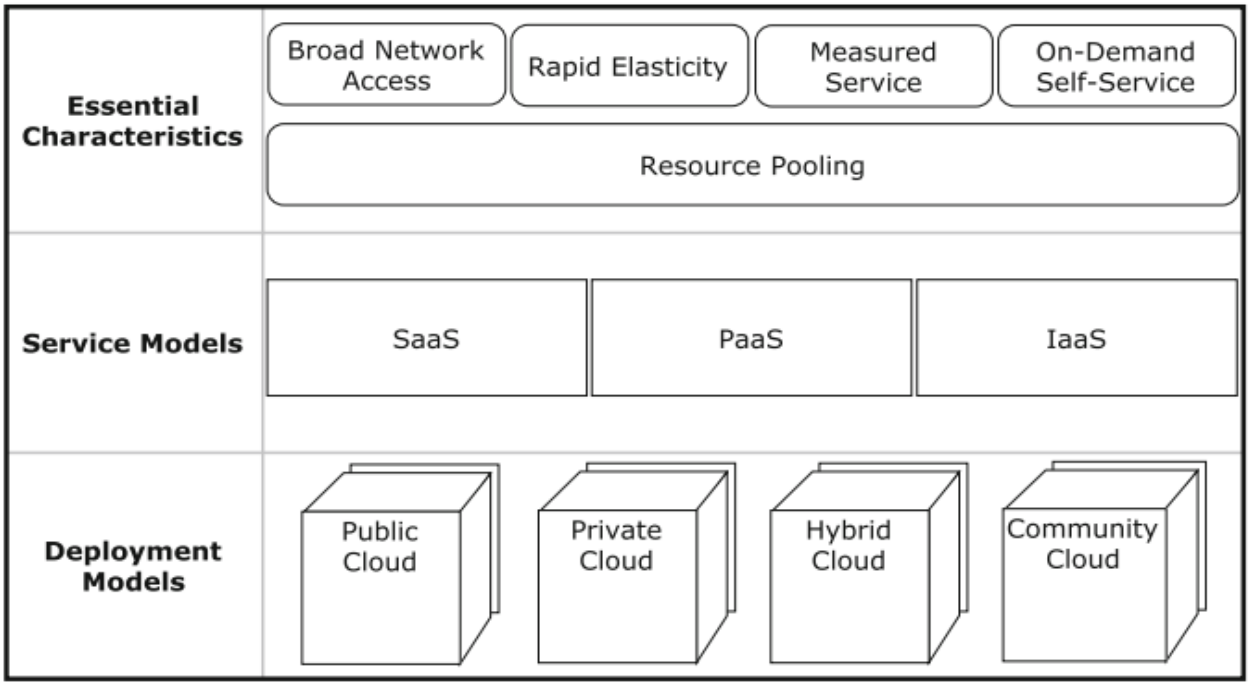



Figure 2. 1: NIST reference architecture.[14]

### 2.1.2. Cloud computing Service models

The U.S. National Institute of Standards and Technology Laboratory definition of cloud computing describes three service layers[13][15].

- ✓ Software as a Service (SaaS)
- ✓ Platform as a Service (PaaS) and
- ✓ Infrastructure as service (IaaS)

#### 2.1.2.1. Software as a Service (SaaS

The SaaS customer is an end-user of complete applications running on a cloud infrastructure and offered on a platform on-demand[15]. The applications are typically accessible through a thin client interface, such as a web browser[16]. The customer does not control either the underlying infrastructure or platform, other than application parameters for specific user settings.

#### 2.1.2.2. PaaS (Platform as a Service)

In the case of PaaS, the cloud provider not only provides the hardware, but they also provide a toolkit and a number of supported programming languages to build higher level services (i.e. software applications that are made available as part of a specific platform). The users of PaaS

are typically software developers who host their applications on the platform and provide these applications to the end-users. Programming platforms and tools (such as .NET, java or python) [17]and APIs for building cloud-based applications and services are exposed to developers who can create applications for testing or for commercial purposes for a minute fraction of the cost of provisioning server infrastructure for themselves[18]. Google's App Engine allows developers to write programs to run on Google's infrastructure or platform. Other examples include Amazon Simple Storage Service (S3), Azure Storage, and Force.com[19].

#### 2.1.2.3. IaaS (Infrastructure as a Service)

The capability provided to the customer of IaaS is raw storage space, computing, or network resources with which the customer can run and execute an operating system, applications, or any software that they choose[20]. The cloud customer is not able to control the distribution of the software to a specific hardware platform or change parameters of the underlying infrastructure, but the customer can manage the software deployed (generally from the boot level upward)[21].

### 2.1.3. Cloud Computing Deployment Models

Clouds can also be classified based upon the underlying infrastructure deployment model as Public, Private, Community, or Hybrid clouds[22]. The different infrastructure deployment models are distinguishing by their architecture, the location of the datacenter where the cloud is realized[3], and the needs of the cloud provider's customers (for example, due to regulatory, legal, or other requirements)[9]. The figure below clarifies the deployment models and the different locations.

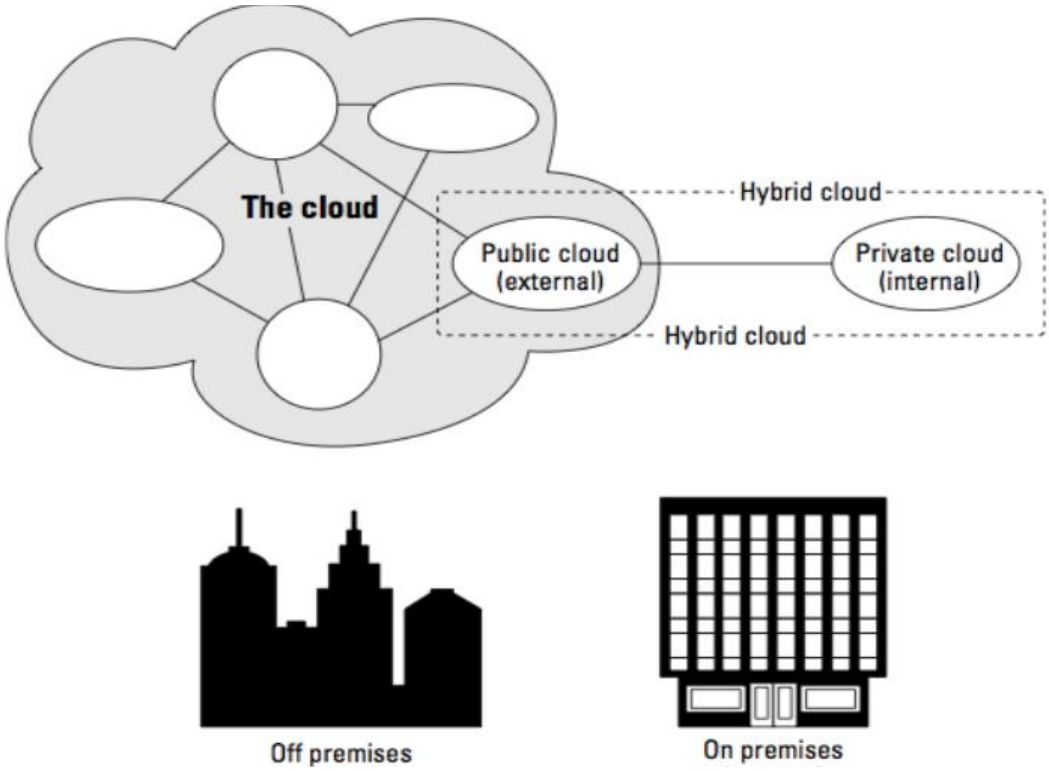



Figure 2. 2 Deployment location for different cloud types [10]

#### 2.1.3.1. Public Cloud

A public cloud's physical infrastructure is owned by a cloud service provider. Such a cloud runs applications from different customers who share this infrastructure and pay for their resource utilization on a utility computing basis. Public clouds are most often hosted away from customer premises, and they provide a way to reduce customer risk and cost by providing a flexible, even temporary extension to enterprise infrastructure. If a public cloud is implemented with performance, security, and data locality in mind, the existence of other applications running in the cloud should be transparent to both cloud architects and end users.[10]

Indeed, one of the benefits of public clouds is that they can be much larger than a company private cloud might be, offering the ability to scale up and down on demand, and shifting infrastructure risks from the enterprise to the cloud provider, if even just temporally[23]. Portions of a public cloud can be carved out for the exclusive use of a single client, creating virtual private datacenter. Rather than being limited to deploying virtual machine images in a public cloud, a virtual private datacenter gives customers greater visibility into its infrastructure.

#### 2.1.3.2. Private Cloud

A pure private is the Cloud which operates dedicatedly for a single organization. Private cloud infrastructure may be set-up On-Premise or off-premise and may be managed either internally or by third-party service providers. Private clouds offer highest level of security and control but are expensive[24].

A private cloud is built for the exclusive use of one customer, who owns and fully controls this cloud. Additionally, there are variations of this in terms of ownership, operation, etc.[25]. The fact that the cloud is used by a specific customer is the distinguishing feature of any private cloud. A private cloud might be owned by the customer, but built, installed, and managed by a third party rather than the customer. The physical servers might be located at the customer's premises or sited in a collocation facility.

A recently introduced alternative to a private cloud is a 'virtual private cloud'. In such a virtual private cloud a customer is allocated a private cloud within the physical infrastructure of a public cloud. Due to the allocation of specific resources within the cloud the customer can be assured that their data stored on and processing is done only on dedicated servers (i.e., these servers are not shared with any other customer of the cloud provider). An example would be the NASA's Nebula Private Cloud which is an infrastructure-as-a-service implementation for scientific data and Web based applications[26].

#### 2.1.3.3. Community Cloud

Community cloud is the Cloud whose infrastructure is shared by several organizations and support a specific community that has shared concerns[12]. The community Cloud may be managed by organizations collectively or by a third-party Cloud services provider. When several customers have similar requirements, they can share an infrastructure and might share the configuration and management of the cloud. This management might be done by themselves or by third parties.

#### 2.1.3.4. Hybrid Cloud

Though public clouds allow enterprises to outsource parts of their infrastructure to cloud providers, they at the same time would lose control over the resources and the distribution management of code and data[27]. In some cases, this is not desired by the respective enterprise. Hybrid clouds consist of a mixed deployment of private and public cloud infrastructures so as to achieve the maximum cost reduction through outsourcing whilst maintaining the desired degree of control over e.g. sensitive data by employing local private clouds. There are not many hybrid clouds actually in use today, though initial initiatives such as the one by IBM and Juniper already introduce base technologies for their realization [18].

### 2.1.4. Cloud Computing Reference Models, Architectures, and Frameworks

Standardization is currently a vibrant concern in Cloud Computing. Creating reference models, architectures, and frameworks for Cloud Computing was of top priority in the Cloud Computing agenda [15]. For this reason, this section will investigate the Cloud Computing reference models, architectures, and frameworks.

#### 2.*1*.4.1 The Definition of Cloud Computing Reference Model, Architecture, and Framework

In software engineering, a reference model (RM) is an abstract, conceptual, technology independent framework, which represents a set of domain concepts and the relationships between them. It is usually used by domain experts who are working independently toward a standard [23].When reference model concepts are arranged in a specific order (pattern) to provide a specific solution for recurrent problem, the generated architecture is called a reference architecture (RA) [24]. Together, the set of RMs and RAs create a reference framework (RF). While it is important to use the correct terminology when describing models, architectures, and frameworks, formality is absent from several works that have been recently published in the domain of Cloud Computing [13]. For example, both IBM and NIST Cloud Computing Reference Architectures are more reference frameworks than reference architectures [12].

#### 2.1.4.2. The Need for Cloud Computing Reference Architectures and Frameworks

There are several reasons for creating cloud reference architectures and frameworks. As explained earlier, reference architectures and frameworks are used by domain experts and standardization bodies to exchange domain knowledge in implementing a standard.

Reference frameworks are helpful for organizations while implementing or adopting a new technology. Cloud architecture reference models provide consistent and coherent architectural representations, and fundamental principles that can be used in the design and implementation of different projects. By having a cloud reference framework, cloud providers or their creators can apply best practices and guidelines to build their own clouds.

Reference models can help providers focus on their distinctive advantages while making sure that they implemented all of the essential components. Furthermore, cloud providers can address interoperability issues with other providers at the early stages of the implementation, by providing support for the required interfaces for inter-cloud communications.

Cloud reference architecture and frameworks can also help developers effectively exploit services. For example, cloud specific reference models such as the one proposed in the paper "A Reference Model for Developing Cloud Applications" [13] can help cloud application developers understand cloud application requirements, and can guide them toward better architectural decisions that are independent of any cloud development environment. Such a reference model can boost the developers' learning curve and increase their productivity by providing them with the main principles of how to effectively reuse existing components and services in design and implementation.

#### 2.1.4.3. Comparison between Cloud Computing Reference Frameworks

As explained in the previous subsection, different Cloud Computing reference frameworks, models, and architectures are either developed or are currently being developed. The question is how these frameworks differ from each other, and how to select the framework or model that best fits your needs. Figure 2.3 is a classification of Cloud Computing reference frameworks based on the current frameworks in the market.

The most obvious distinction between current reference models and frameworks is that some of them are generic while others focus on specific areas. The NIST has recently compared six

generic Cloud Computing Reference Architectures and five specific ones [13]. The analysis of current reference frameworks reveals that these frameworks can be decomposed first, into reference models, which consists of architectural elements and their relationships; and second, into architectural styles and principles, which represents a set of rules and guidelines that ensure enforcing best practices in methodical ways.

According to Wilkes [25], Role-Based CCRM maps services and activities to roles. Examples of role based frameworks include: Cloud Service reference architecture [34], the IBM Cloud Computing CCRA [21] and the NIST CCRA [26]. Almost all role based reference frameworks recognize the Cloud Service Provider and Cloud Service Consumer roles. Other roles depend on the framework's level of detail.

There are lots of similarities between NIST and IBM CCRAs[13]. Figures 2.3 and 2.4 show the IBM Cloud Computing Reference Architecture and the NIST Cloud Computing Reference Architecture, respectively. While some architectural components are exactly the same, others have different wordings or are implicitly contained within other architectural components. Both NIST and IBM CCRAs are comprehensive frameworks. However, this does not mean that they are complete; in fact, there is no complete cloud reference framework to date. One of the strengths of the IBM CCRA is that it goes one step further and identifies some of the Cloud Computing architectural principles and guidelines as well as the Cloud Computing Management Platform (CCMP). Other reference models focus only on the relations among cloud services as well as the roles of the different cloud stakeholders. While identifying the roles, services, layers, and their relationships is important, a reference framework cannot be completed without the set of architectural styles that identify the different scenarios and best practices in a methodical way.

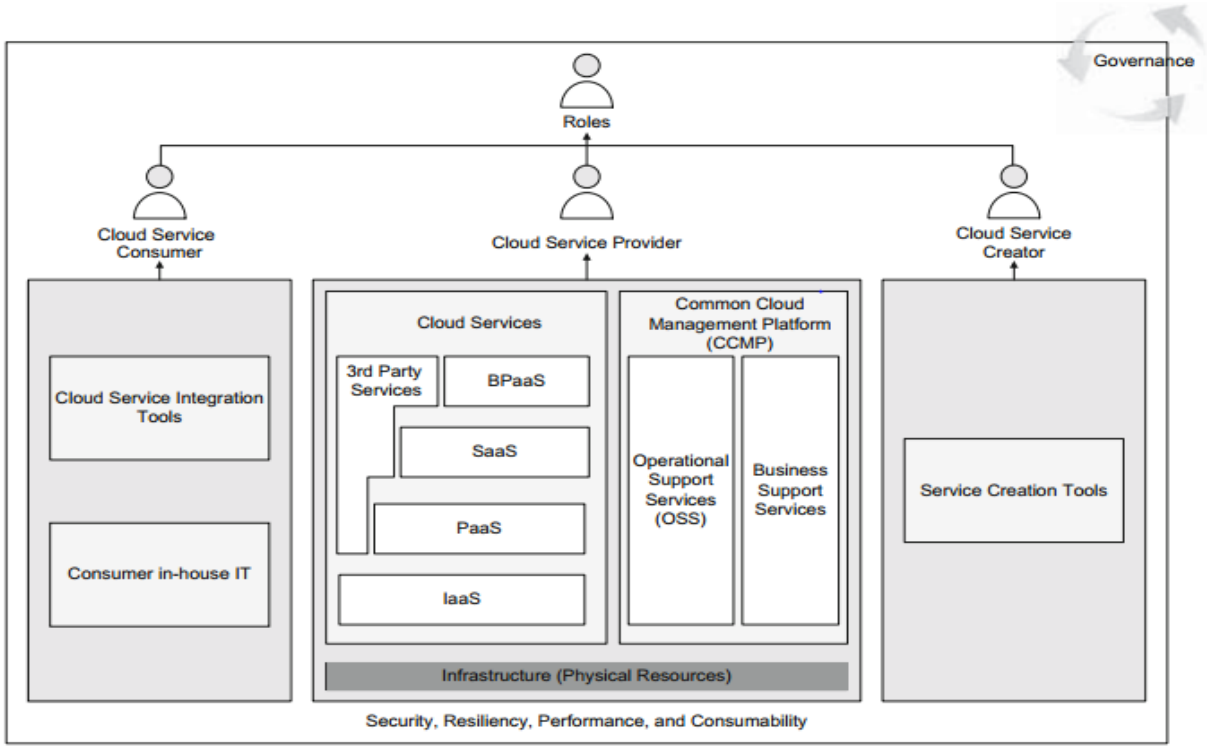



Figure 2. 3 An overview of the IBM Cloud Computing Reference Architecture [13][28]

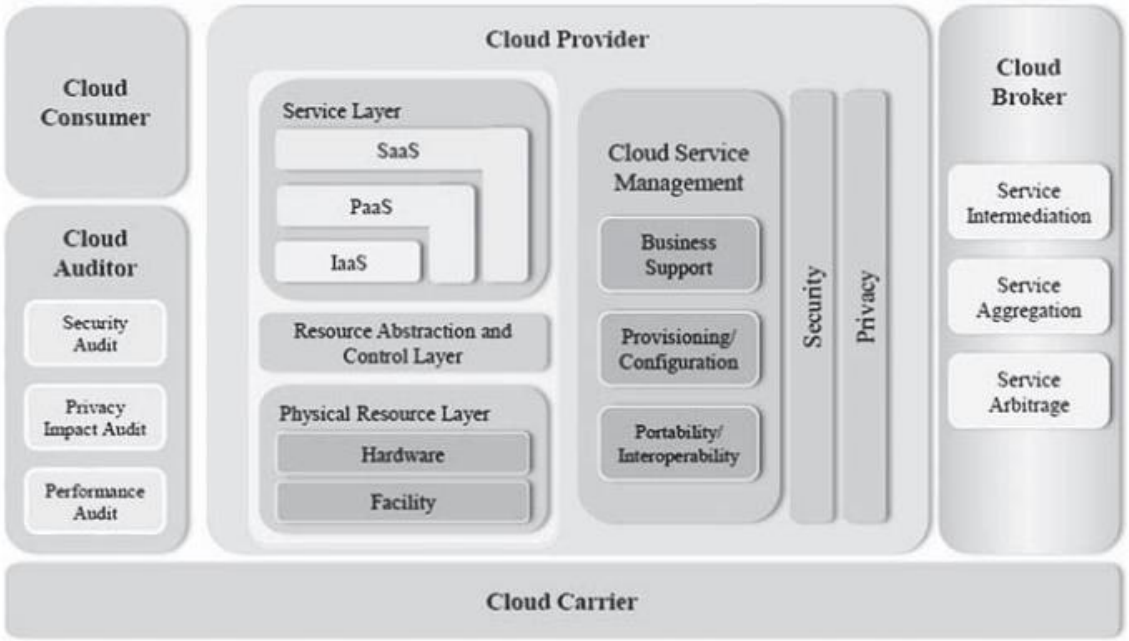



Figure 2. 4 NIST Cloud Computing Reference Architecture overview [13][10]

### 2.1.6. Cloud Computing and Education

The education sector is one of the cornerstones of socio-economic development[29]. It is widely accepted that education contributes to poverty reduction and increased economic growth, which in turn leads to an improved standard of living. It also enables the individual to participate in wealth generating activities, leads to the creation of employment, and the overall development of society. Like other sectors, the education sector has also felt the effects of the meltdown, with some countries reducing their budget for education.

However, with governments making concentrated efforts to ensure that education remains a top priority, the sector is on an upswing[5][8]. This is primarily because education is considered to be an essential in economic turnaround. Both the Ethiopian government and private players are investing in the education sector to leverage opportunities in the sector. The Ethiopian government has taken several initiatives to promote Education in Ethiopia.

### 2.1.7. Cloud computing for Ethiopian Higher Education Institution

Now a day, many organizations including education sector are shifting their ICT paradigm from traditional data center to cloud based services for the improvement of services with lower costs and better efficiency. So the suitable use of advanced ICT in education is needed to meet the social demands especially in developing countries where high-quality Internet service is not available and the prevalent lack of educational resources. It is well recognized that in the future, developing countries would play a key role in sustainable development more than before where opportunities of higher education were limited [18].

Ethiopia as a developing nation has suffered by limitation of educational budgets. HEIs are being built in very high speed. Currently there are around 36 government owned universities and many private colleges. Without quality education establishing educational institutions by itself cannot give the solution we seek for economic development and poverty reduction through education. Education should be supported through up-to-date technologies and services. Ethiopian government has been investing millions of dollars every year to support education in higher education institutions with technology. However due to struggling economy it is not able to supply full ICT infrastructure requirements of all universities. As it has been discussed in the previous sections this infrastructure requirements can be solved using cloud computing strategy

.i.e. implementing a central Hybrid Cloud [8] based architecture for educational resources sharing that can be used by all HEIs of Ethiopia. The proposed Cloud based Architecture deployed based on a public cloud.

The private cloud is implemented and managed by in higher education institutions in collaboration with the MOE data center. Every resource that will be share by multiple universities will be placed at the public cloud models and then it will be available to all hosted universities. Example, it is true that every university have used different curriculum in the same department or faculty or course. This makes somehow a variation in the teaching and learning process. So to make it this same environment, to create accessible by the teachers, researchers, students or any staff members, such like centralized system should have to develop.

In order to have access this system there is no need of to deploy a system for all 34 universities. If we these for all university, the cost of the ICT infrastructure is very highly, But this cost can be significantly reduced by deploying a single copy of A centralized system in to the proposed a cloud based architecture on the hybrid deployment model. The hybrid development model will have an interface from its Ethiopian Universities Private Cloud (EUPC) [5][8]to public Cloud Service Providers. Whenever some resources will not be deployed into EUPC due to different factors then through the public interface it is possible to access the resource from the main data center .By deploying Hybrid cloud computing model, the fear of privacy and other related security issues can be avoided, since critical and sensitive data could be owned by university members and responsible bodies from Ethiopian Ministry of Education.

#### 2.1.7.1. Adoption of Cloud Computing in Higher Education

Higher education is the most substantial pillar for the country's development. Through the partnerships between universities, government and industry, researchers and students have proven their contribution to the transformation of society and the entire world economy[30]. In the field of education, Cloud Computing is very practical for a variety of reasons. Indeed, Cloud Computing will enable a certain educational institution to actually make use of the global internet resources for data analysis and data storage[31] .

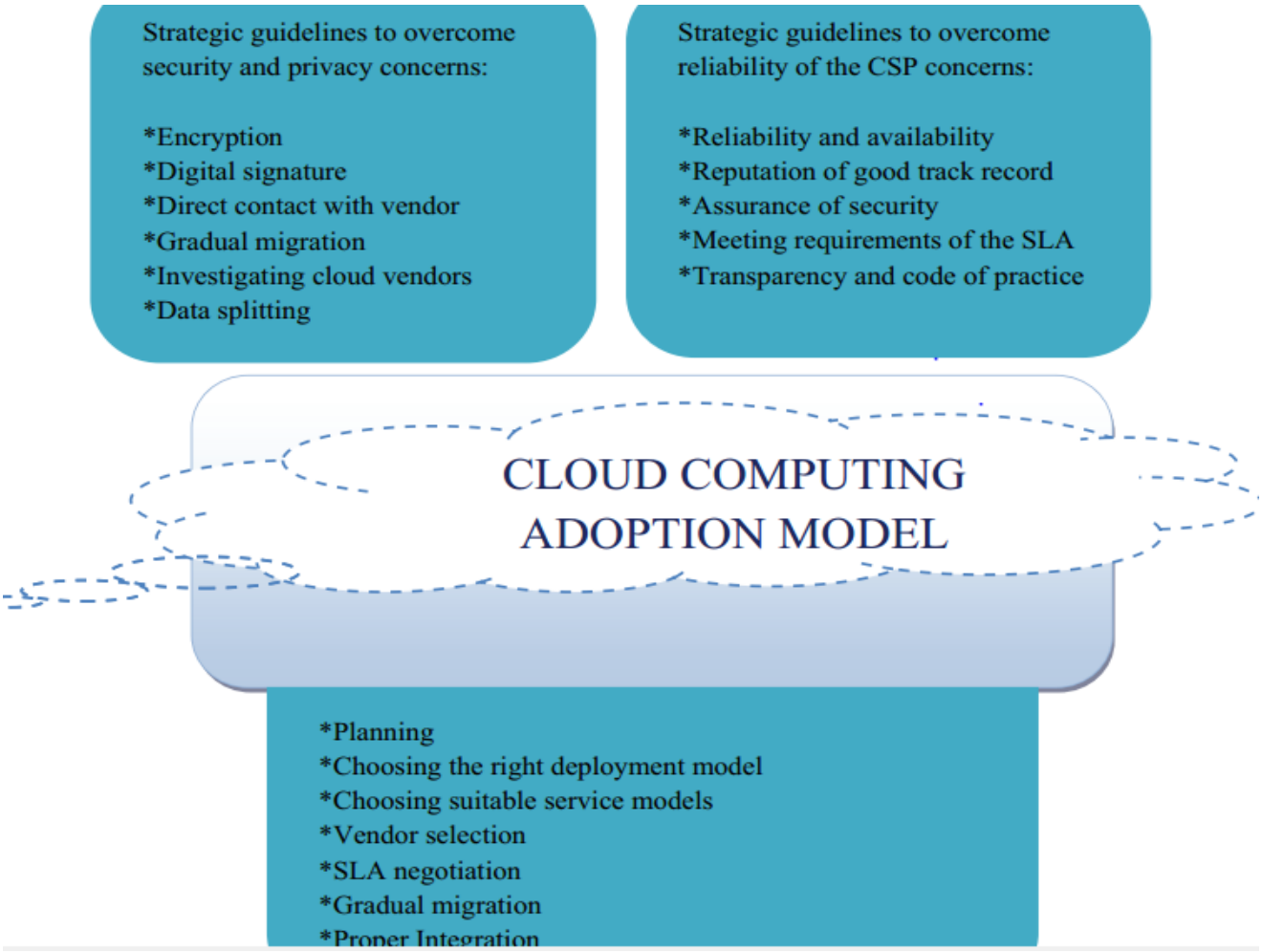



Figure 2. 5 Cloud computing adoption model [33].

#### 2.1.7.2. Challenges of Cloud Computing In Higher Education

Many challenges of Cloud Computing for Higher Education exist related to the relatively new and rapidly Cloud computing services. For Higher Education, decisions to adopt Cloud Computing will be influenced by more than technical and cost considerations [19]Information is the life blood of higher education, and decisions on how to manage educational resources, data and information can have far-reaching political, social, and economic considerations on the students, faculty and the society.

The adoption of Cloud Computing causes many risks and challenges such as deciding to use a more traditional outsourcing arrangement. The academic institutions need to weigh the costs and benefits; but a major factor of these decisions will be their level of trust in both the cloud deployment model under consideration and the entity providing it.

There are several influential factors of adoption Cloud Computing, the following factors had analyzed and identified the possible risks and opportunities [32][33].

### A. Reliability

An outage is the absence of the cloud service. It might 24 happen for a short or a long time, a few or many times. Even large companies such as Google and Amazon experienced many similar cases in the past and they will have many more in the future. In short, 100 % availability of the service is impossible. Actually, most of the applications hosted in the cloud are currently non-critical such as back up and software testing. Moreover, users who are using Cloud Computing solutions should make sure to have backup of their data in other places. Nowadays, Cloud providers are trying to avoid outage and promise a high level of availability in the Service-Level Agreement (SLA) and try to compensate their users in the case of an outage of the service. This factor represents a risk and it is one of the effective factors in Cloud Computing adoption.

### B. Security

Users of Cloud Computing give the cloud provider full control over their data and they should trust that this third party will take care of their business, secure the data, and do backups for them. This issue can be partly solved by Service-Level Agreements (SLA) where the conditions of security issues in the contract will be clarified. Found that the security issue is one of the biggest doubts when users think about adopting Cloud Computing as the users do not have their own data in their companies anymore. "Our findings suggest that in respect to both SaaS adopters and no adopters, security threats are the dominant factor influencing IT executives' overall risk perceptions" [34].

Finally, the cloud providers today are employing the latest technologies and the highest standards in securing their servers and hosted applications. "We believe, however, that the clouds are not less secure than on premises computing systems" [22] ;also agrees that this issue is being enhanced now and it also has some advantages by giving the company more control options over their data.

In conclusion, security issues can be seen as an opportunity and a risk at the same time, but it is mainly a doubt as it is seen by cloud adopters and non-adopters. It plays an important role in determining the kind of applications which are taken into the cloud and the industry type which

can adopt cloud solutions. For instance banks, hospitals, and governments are used to avoid adopting cloud solutions because of the security concerns [22].

### C. Performance

The main source of performance problems come from the connection quality between the user and the Cloud Computing server, mainly when more users are connecting at the same time and large amounts of data are transferred between the end user and the cloud server. This results in a slowdown in the cloud service [22].The performance issue is an important factor which companies have to think about when adopting Cloud Computing. Companies should measure their possible current and future bandwidth and processing requirements before they decide to adopt Cloud Solutions. Performance is seen as one of the main risks, and an important opportunity at the same time [34].

### D. Scalability

Scalability is an important factor that should be taken into account in terms of performance. As the requirements of the Cloud Computing adopters increase, the cloud provider should be able to scale up their resources and infrastructure to satisfy the adopter's new requirements of storage, processing, and connection bandwidth [22].On the other hand, scalability in Cloud Computing is one of the main strength points and constitutes an important opportunity for companies. As these companies' requirements change, their infrastructure will be scaled up or down dynamically providing a high level of strategic flexibility [22] [34].

### E. Compliance and Physical Location

Since Cloud Computing is a fairly young technology, no rules and governmental regulations really exist to set the boundaries and laws regarding the storage of data by enterprises on third-party computing facilities that are shared with others. Moreover, some old regulations already exist concerning the enterprise data privacy, access, and location without taking Cloud Computing into account, and these regulations might be violated by Cloud Solutions [4].

For instance, while many countries have regulations concerning the physical location of enterprise data, the cloud providers cannot guarantee the exact physical location of the data, and

even some of them have policies to hide such kind of information from the end user. However, some companies are now trying to solve this issue and comply with the local regulations.

### F. Integration with other Services

Companies need to adopt different types of applications from different cloud providers and these applications might need to interact with each other. At the same time, some companies might adopt a hybrid strategy of Cloud Solutions as public clouds have different characteristics from that of private clouds. Consequently, the integration between the data from these different applications needs to be achieved and this issue poses many technical and business challenges for cloud providers and adopters[35][36].

### 2.1.8. Benefit of Cloud Computing Applying to Educational Resources Sharing

We investigated whether the Cloud computing can solve part of the problems, while other parts cannot be solved and even new problems are raised. We can find cloud computing is very suitable to tackle the technical problems such as low degree of standardization, lack of interoperability between educational resource repository systems ,lack of cooperatively work among higher educational institutions, lack of accessibility resources anywhere using any devices, and different technical maintenance abilities.

At first in cloud computing model, we can design a virtual educational information resources repository[37]. An all data is uploaded and storage into this virtual repository. Although the real repositories consist of the virtual repository may distribute on different place and organization, the cloud computing technology ensures much of the difference between the real repositories is transparent to both the users and the system managers. So standardization and interoperability are improved. In additional, there is only a high-level technical maintenance team required in the cloud computing center and less or no technical main tenant team on the real repositories' side.

- ✓ **Cost Savings**

The educational institutions are under a great pressure of delivering the best quality education from constraint financial budgets. Cloud computing helps to cut down hardware costs, software

up gradation costs, and leads to huge financial savings. The reduction in power consumption of thin clients compared to PCs leads to great savings in electricity bills.

- ✓ **Improved Accessibility**

Cloud services significantly help to improve the access of data from anywhere and anytime. In 21st century, students are expected to acquire communication and collaboration skills as an integral part of learning. Cloud computing tools enable to collaborate with others by sharing data and work together as a team, for instance, Google docs. The concept of storing the work done in an institution in public cloud enables student to access the data from anywhere and will remain as a record for future reference.

- ✓ **Resource Pooling**

Resource pooling of cloud distinguishes itself from thin client computing, where only limited amount of resources are available to the user [14]. Moreover, cloud resource sharing will give the following benefits to the users:

- ✓ Ubiquitous availability of educational resources irrespective of time constraints.
- ✓ Increased user satisfaction level.
- ✓ Huge saving of efforts and time avoiding duplication and inconsistency of the educational resources.
- ✓ Allowing of users from accessing any educational resources which are not found in their home university.

### 2.1.9. Cloud computing Resource Sharing Adoption Framework

Technology means different things to people at different times, and it can be difficult to imagine what the future has in store for us and the technologies that we are currently using in the libraries [34]. Any organization like libraries when decides to move its services from ground to Cloud there is need of strategic planning and decision taking. To imply cloud computing in resource sharing there is need to frame adoption strategies and framework[31]. A cloud based resource sharing adoption framework has been presented below:

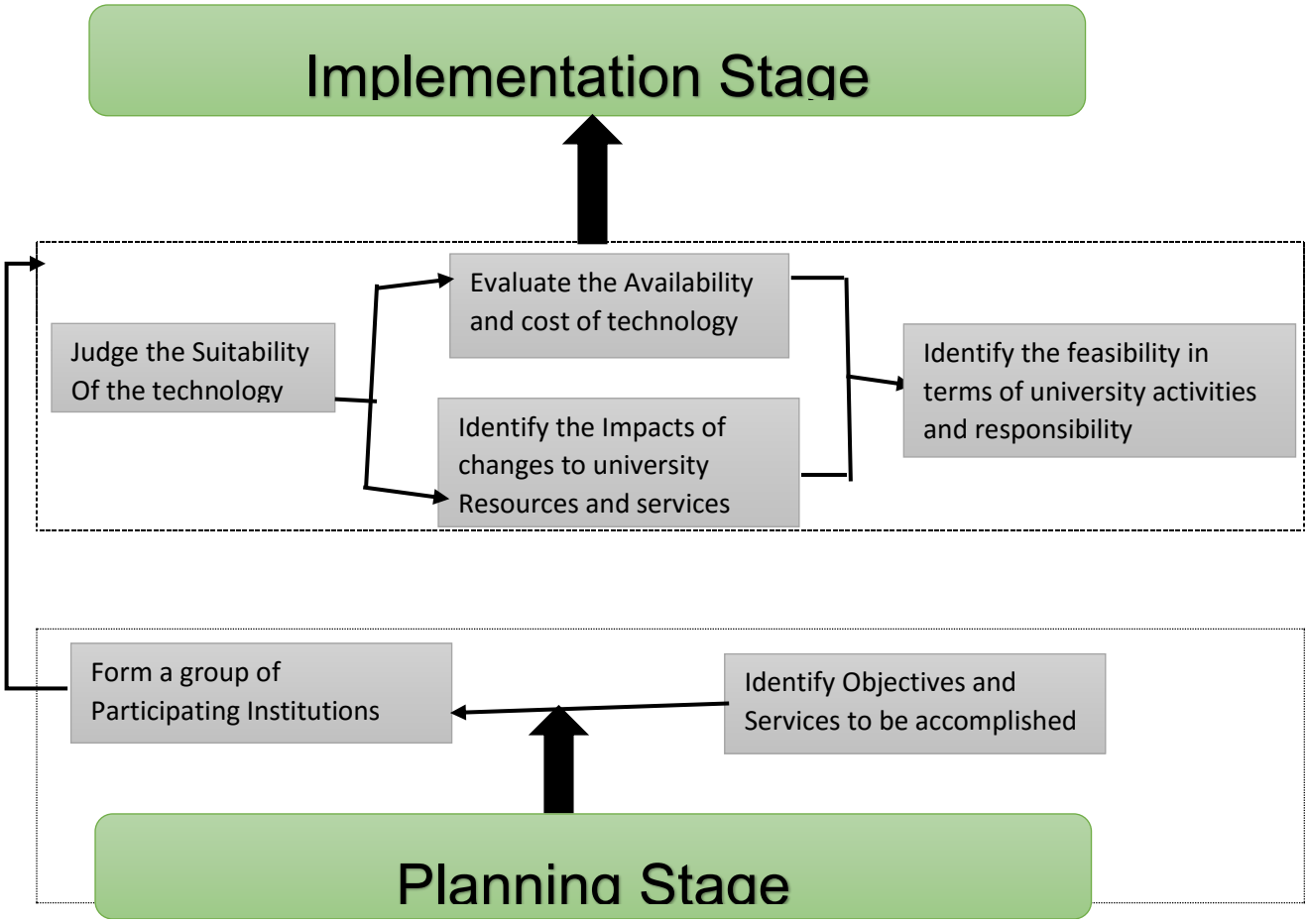



Figure 2. 6 Cloud computing Resource Sharing framework [39]

The cloud resource sharing adoption framework is divided into two stages: planning and implementation[38]. In planning stage a group of participating Universities for resource sharing is formed. This group then drafts the objectives and the services that they want to accomplish through –resource sharing. After planning of the course of actions for resource sharing we come to the implementation stage. The first step in the implementation stage is to judge the suitability of cloud technology and the library user's satisfaction level. Then an estimate of costs and energy consumption in offering library services in the cloud is found out. Also, the impact of shifting the library services in the cloud is properly evaluated by the participating libraries. Lastly, a feasibility study of cloud based resource sharing is comparatively studied with ongoing library activities and responsibilities in a brick-and-mortar based library. In case of satisfaction the resource sharing activities of libraries are initiated in the cloud otherwise libraries again focus on planning stage and redesign their goals and concern areas[37].

## 2.2. Related Works

Many researchers around the globe are trying to explore the possibilities that cloud computing has to offer, and are formulating new cloud based models, architectures and frameworks that would help to optimize and properly utilize information and communication technology on the efficiency of different solutions when deployed in various sectors like education, finance, health care etc. In the recent years there have been many publications on different applications based on cloud computing, both in general and in research. But in this section, we discuss some of the works that are done on cloud computing related to education sector and especially in higher education institutions.

Elamir et al. [39]present a framework naming programming education environment as cloud computing services to teach computer programming. E-learning applications include educational objectives, content production, content delivery technology, assessment and management component. This framework combines the elements from current practices of E-workbook, ELearning and cloud computing technologies. C++ Workbook as cloud service was implemented to validate the proposed framework. Other services are matters of future work such as logging of programming activities, program plagiarism detection, programming workbook and automatic marking [39].

It is an attempt by Bouyer et al. [40] to develop ELearning system by utilizing cloud computing environment. Another objective is to emphasis on the importance of virtual education to improve the quality of education by applying cloud computing environment. Students can get a range of enormous computing resources anywhere, anytime, less learning time and less cost. Some of the benefits of CC education are improved educational services to enhance teaching and learning in short time span, economical, reduce risk, and improve security and strong collaboration [12].

Mohamed Sirelkhtem Adrees[7], in this research work the researcher focus on big threats in developing country educational systems. There are a range of educational and technical problems in the least developed countries. Especially in Sudan that to clarify and highlight: Weakness of government funding for the education sector, the lack of infrastructure and buildings suitable for higher education, Migrations teaching staff And Lack of educational resources in the higher

education institutions is the main problem mentioned by the researcher the researcher takes republic of Sudan as a model.

So to address these problems, the researcher proposed cloud computing architecture in higher education institutions to provide a solution through cloud computing to give some solutions, such as: Virtualization of computing environment, Sustainable environment for higher education for the deployment of each and every educational resource.

Shaik Saidhbi, et.al. presents [8] Cloud Computing Framework that can be used by Ethiopian Higher Education Institutions, which would enable service delivery much more efficient and effective than the current system.in this research the researcher proposed a framework that will utilize the existing IT infrastructure for institutions which would adapt the framework namely, Ethiopian Universities Hybrid Cloud (EUHC).

This framework will expect to give a better utilization and cost reduction in information and communication technology. To build a powerful hybrid Cloud solution which utilizes the current Ethiopian Universities IT infrastructure (private Cloud), the researcher proposed to use Aneka middleware on top of Opennebula. The combination of these two open-sources provided a manageable hybrid Cloud for the institutions. This approach will utilize the universities IT infrastructure more efficiently, and it provided additional resources when the Universities' IT infrastructure was at the peak time and could not provide all the requested resources, such as storage and computing power. But, in this research papers the authors didn't test the framework in a prototype system.

Shahid Al Noor et.al[27] presents a cloud architecture to use the limited resources in a most efficient way and they made a comparative analysis between the existing architecture and the new proposed architecture. In addition, they introduced four different types of services on the proposed architecture.[27]

Gang Zhao et.al [30] studies the current situation of domestic and foreign cloud computing education, proposed the strategy of constructing information resource libraries in universities under the environment of cloud computing, and studies how to construct the network educational resources platform in institutions of higher learning under the cloud model. Here the researchers suggests that with respect to the co-construction and sharing of teaching and learning resources,

cloud computing models has the most obvious advantage for educational institutions to create a comfortable teaching and learning environment.[30]

Meanwhile, the researcher also enables a strategies for educational institutions how to share their resources with others, thus realizing the openness and sharing of educational resources. In this way, the existing problems of educational resources such as low degree of resource sharing, lack of communication and collaboration as well as uneven resource distribution can all be effectively addressed. So to address and to enable teaching resources sharing in educational sectors, the researchers have tried to design a strategies for "Teaching Resources platform" based on cloud computing.

Caifeng Zou et.al [41]The researchers proposed a new model of hybrid cloud computing architecture based on cloud bus. The system is based on local private cloud, combined with one or more types of public cloud. The proposed model of the architecture can accelerate the migration of the existing IT environments to cloud computing environments, reduce the investment, and make full use of IT resources. The hybrid cloud computing architecture based on cloud bus, just the researcher add a cloud bus layer on the architecture which enables to integrate easily another services or with cloud service providers to the proposed architecture. This cloud bus layer, consisting of a control bus, a number of node buses and adapters, is designed to manage and monitor the various services of the cloud platform layer. The cloud application layer contains SaaS and PaaS service applications. The cloud bus architecture uses one bus controller and multiple bus execution agents to manage, simplify and enhance the integrative topology between applications. The researchers also used Open Stack technology to implement the infrastructure layer, the platform layer is implemented by Cloud Foundry technology, the auto-upgrade of the system is implemented by Puppet technology and for the storage center consists of object database, file database, relational database, and other database.

Bariah Aljebreen et.al [42] focus on a comprehensive study on scientific literatures in order to find out the opportunity and risk of cloud computing in educational fields. This paper also presents the significant information such as the findings, the case studies, related frameworks and supporting also the tools associated to the migration of organizational resources to cloud. Meanwhile, the researcher suggests and designs a supplementary strategies when migrating in to the cloud computing service provider especially in kingdom of Saudi Arabia,

To summarize the related research works, all the above researcher didn't touch the problem of educational resources sharing platform among higher education institution to enable them share higher educational resource. None of the researcher develops the architecture to enable sharing and accessing the educational resources anywhere, any device. So to enable these, we propose to design a cloud based Architecture for educational resource sharing which improves the ability of document sharing in higher education institutions.

**Table 2.1.Achievement and limitation of Related Works and our work.**

| Title | Achievement | Limitation |
|---|---|---|
| Framework And Architecture For Programming Education Environment As a Cloud Computing Service[39] | • Framework is developed for programming educations as a cloud service. | • Services such as logging of programming activities and content service delivery lift as future work. |
| Usability of Cloud Computing to Improve Higher Education[40] | • Cloud computing techniques identified to improve higher education learning process. | • The researcher considers only usability of cloud computing for students in higher Education.<br>• Cloud computing platform selection. |
| A Cloud Computing Framework For Ethiopian Higher Education Institutions[8] | • Framework is developed: used for just a road map for the implementation of a virtual cloud based teaching learning process. | • The proposed framework is just as a roadmap(other services of the framework as a matter of future work)<br>• Testing of the framework using cloud service delivery model. |
| Advances In Higher Educational Resource Sharing And Cloud Services For Ksa[42] | • Cloud computing adoption Framework and cloud computing migration strategies. | • The need for further researches to design the framework to identify requirements in education, cultural and political related problems |
| Applied Research of Cloud Computing on the Sharing of Educational Information Resource[30] | • Supplementary Strategies of Applying Cloud Computing to Educational Information Resources is designed. | • Specified cloud computing architecture, cloud computing model and platform. |
| Cloud Computing Architecture For Higher Education In The Third World Countries[7] | • Educational and technical problems in the developing countries are identified and a cloud based solution is proposed. | • A proposed cloud computing architecture and cloud computing service delivery model. |
| A Proposed Architecture of Cloud Computing for Education System in Bangladesh[27] | • Architecture was developed to use limited resource in an efficient way. | • Developing the prototype system using a cloud based platform |
| **Our Proposed System:**A cloud Based Architecture For Educational resource Sharing in Ethiopian HEI(own work) | • Education resource sharing using cloud computing in HEI were assessed and examined<br>• The proposed architecture is designed,<br>• The prototype system is developed. The architecture and prototype system is tested and validated | • Implementation of the architecture on hybrid cloud deployment model.<br>• Testing the architecture online by creating virtual machine in window azure platform. |

# Chapter Three: Methodology

## 3.1. Introduction

Since the purpose of this research is to design of a cloud based architecture for educational resource sharing for Ethiopia higher education institutions; mixed research approach have been used and the descriptive analytical approach is used for analysis purpose in this research.

## 3.2 Research Design

In this study, mixed research approach have been used so as to know if cloud computing technologies are being used in Ethiopia public higher educational institutions during the time of research and to identify the role and significance of used cloud services in this field. Employees of three higher educational institution teachers and ICT center workers in Ethiopia were used as respondents in order to gather relevant data; the three higher education institutions selected based on the experience and size of the institutions and random sampling is employed to select the three HEI; mixed research approach is then appropriate as this can allow the identification of the similarities and differences of the respondent's answers. So the researcher followed a mixed research design approach.

Mixed methods research is a method for conducting research that involves collecting, analyzing, and integrating quantitative and qualitative research in a single study. The purpose used this mixed research types is, provide a better understanding of the research problem by exploring quantitative data and qualitative data. We used qualitative research type for concept description and development, for designing type and coding; quantitative research type for statically analysis, for comparing user data and for evaluation.

Object-oriented method was used in the design and development of the computerized system following an incremental development process. Functional requirements were gathered and modeled using UML diagrams. Such as use case diagram, class diagram and sequence diagram and class diagram were used to model the high-level and detailed design of the system. Structural and basic requirements were designed and developed first into an operational prototype which is released as the first version/increment subject to evaluation, revisions and enhancements.

**Research Procedure**

- ✓ Identify questionnaire items.
- ✓ First, Identify main fields of the questionnaire and items for each field, and then prepare a preliminary questionnaire for use in the data and information collection.
- ✓ Then, take into account the rules of scientific research from objectivity and comprehensiveness in the preparation of this questionnaire.
- ✓ Then, show questionnaire to the advisor, in order to test their suitability for data collection, and then modify the questionnaire primarily according to the vision of the different bodies.
- ✓ Then, prepare the final form of the questionnaire according to the vision of the supervisor (Appendix A and Appendix B).
- ✓ Then, distribute the questionnaire to (40) in the duration from 28 May to 13 June 2015. Questionnaire were retrieved from (35), in addition to that there are some of research population members who did not fill the questionnaire that were distributed to them, because some of them have heavy work and they have no enough time for filling questionnaire, and some of them are outside Ethiopia, The researcher tried to distribute some questionnaire by email but there were no responses, and there is no existence of errors in the recovered questionnaires due to the educational and professional level of the research population.
- ✓ Then ,organize and code the retrieved questionnaires
- ✓ Finally, analysis the data by using IBM SPSS v22.

## 3.3 Process Models

Process model is an abstract representation of a process. It presents a description of a process from some particular perspective and as a software engineering gained more experience, different software development models were introduced to solve different concerns[43]. Today there is an understanding that there is no one process model that will fit all the software projects .For this study the researcher used incremental process model.

### 3.3.1. Incremental Development

Object oriented methods are built up over time incrementally rather than all at once near the end when changes become expensive. Another reason for applying an incremental development process is that the staff can work more effectively. Developing systems through incremental release requires first providing essential prototyping system (main operating functions), then providing system users with improved and more capable versions of a system at regular intervals.

So Prototyping is a technique for providing a reduced functionality or a limited functional version of a software system early in its development life cycle. In this thesis incremental process modeling includes the following phases:

i. Requirement Specification.
ii. Object Modeling
iii. Platform Selection
iv. Architecture Design
v. Prototype Implementation
vi. Testing and Validation

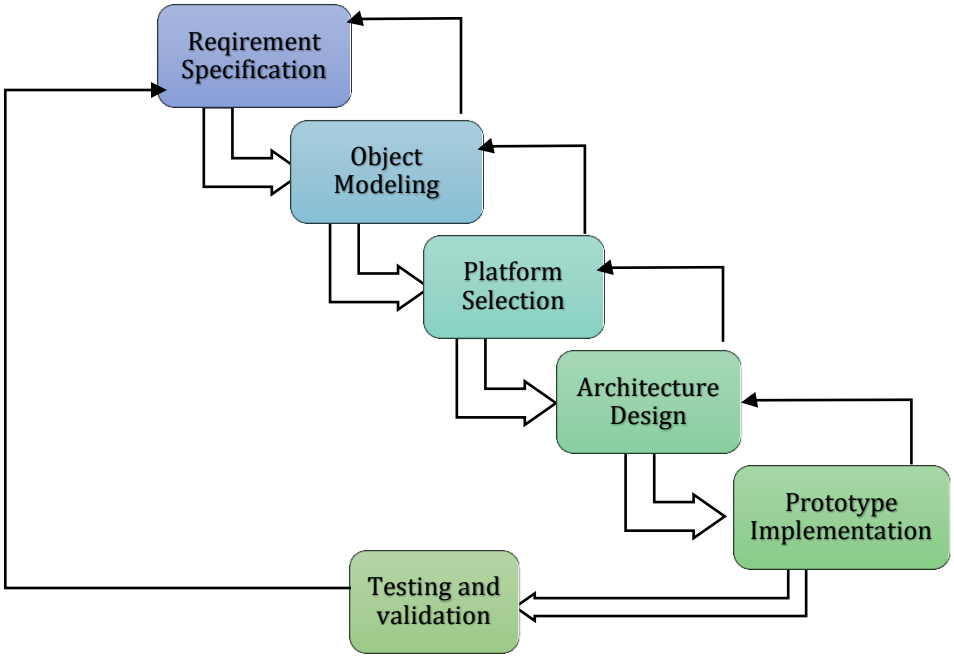



Figure 3.1 Incremental process modeling phase diagram

## 3.3. Data Sources

The data resources can be classified as secondary or primary.so in this study we used the two type of data sources.

**A. Primary Data Resource**

In order to analyze the qualitative and quantitative data of the research, the questionnaire is used as a main tool for collecting primary data. And is analyzed through IBM SPSS v22 statistical software.

**B. Secondary Data Resource**

To introduce the theoretical literature of the subject, the researcher uses the secondary data resource which may include: previous studies, books, academic magazines, periodicals, websites and electronic versions, MoE reports, HEI reports related to educational resources, and published articles related to the subject, this data is essential to gain understanding of the research area and what has already been done.

## 3.4. Research Population

The research population consists of staff with academic and administrative positions. The staff has relations in computer and IT fields at the three higher educational institutions (Dean, Vice Dean, Head of Department, Director, Assistant Director, Lecturer), also the questionnaires are distributed to this population which represents the research population. The research population is identified in terms by the method of the population selection and its size, as follows:

**A. Population Selection:**

The population of this research is selected form Addis Ababa University, Adama science and Technology University and Assosa University based on their generation and by means all of the members of the staff with academic and administrative positions, who have relations in the computer and IT fields at higher education institutions, are included in this research. Table (3.1) shows the statistics of the number of population. This statistic is taken in April, 2015

**Table 3.1 population selection**

| Population | questionnaires Distributed | Retrieved Questionnaires | Percentages % |
|---|---|---|---|
| Dean | 1 | 1 | 100 |
| V/Dean | 1 | 1 | 100 |
| H/department | 3 | 2 | 66.67 |
| Directory | 3 | 2 | 66.67 |
| A/directory | 5 | 5 | 100 |
| Lecturer | 27 | 24 | 88.88 |

**B. Population Size:**

The research population includes a study of each of the Dean, Vice Dean, Director, Assistant Director, Head of Department, Lecturer, and ICT employees at the three Ethiopian higher

education institutions, The population selected according to the research sampling techniques; Where (40) questionnaires are distributed, (35) are retrieved; as the result, the percentage of responses is (87.5%).

## 3.5. Data Measurement

In order to be able to select the appropriate method of analysis, the level of measurement must be understood. For each type of measurement, there is an appropriate method that can be applied rather than others. In this research, ordinal scales are used. Ordinal scale is a ranking or a rating data that normally uses integers in ascending or descending order. The numbers assigned to the agreement degree (1, 2, 3, 4, and 5), do not indicate that the interval between scales are equal, nor do they indicate absolute quantities. They are merely numerical labels.

## 3.6. Data Collection techniques

To collect information about to our objectives and purpose of the study (people, objects, phenomena) and the settings in which they occur. For this research, the researcher used the following data collection techniques and tools. Survey items were based on questionnaires from literature reviews sources and adapted and modified to fit the context of this study.

Data collection techniques such as interview, questionnaires and documentary analysis were used, interview with concerned bodies from Ministry of higher education and addis ababa university information science department staff and ICT center and as well as review of documents and manuals including website of the MOE have been used to gather relevant information for the design of a cloud based architecture for educational resources sharing.

A non-probability sampling techniques called purposive sampling methods were used for primary data sources. This is because only few HEI ICT center worker and staff members with the experience relevant to the study had to be selected. The aim of the questionnaires is to understand the current practice of academic resource sharing, awareness of cloud computing, advantage and disadvantage of cloud computing, risk of cloud computing in higher education institutions and to construct relevant cases for the design of cloud based architecture, three higher educational institution selected and the questionaries' are distributed for the selected three institution staff and ICT employees

For the interviews, we select target population to response the questionaries' since they are target groups that affected by the system. Similarly from the Ministry of Education, there were target staffs concerned with the development and expansion of ICT infrastructure for the higher education institutions who were interviewed to get relevant information for the current ICT infrastructure and technology that they have in each higher education institutions and to assess the emerging technology of cloud computing in higher education institution perspectives and to judge higher education institution in academic resources sharing and coordination . Also an interview was made with department heads of Addis Ababa University information science and software engineering departments and students.

The aim of the interview is to find out what they believe on important attributes ,services and modules for users to share and access educational resources sharing system and to identify the students' needs and interest in academic resources sharing among in each higher education institutions.

Document analysis was made to get general concept of cloud based architecture for educational sectors especially in higher education institution perspective, to understand cloud based architecture in resources sharing, to select best fit platform, service delivers and deployment models for this study, to make analysis for different tools for the architecture implementation .Document analysis also made to understand general methodology of a cloud based web application development, service integration and business operation aspects for this study.

## 3.7. Requirements Specification

Requirements specification is the activity in which the application analyst collects and formalizes the essential information about the application domain and expected functions.

Understanding user requirements is an integral part of information systems design and is critical to the success of interactive systems. It is now widely understood that successful systems and products begin with an understanding of the needs and requirements of the users of system design. We analyzed the requirement specification and we follow the following steps to identify user requirements and the expected functionality:

- ✓ Data gathering
- ✓ User need identification

- ✓ Envisioning and evaluation
- ✓ Requirement Definition

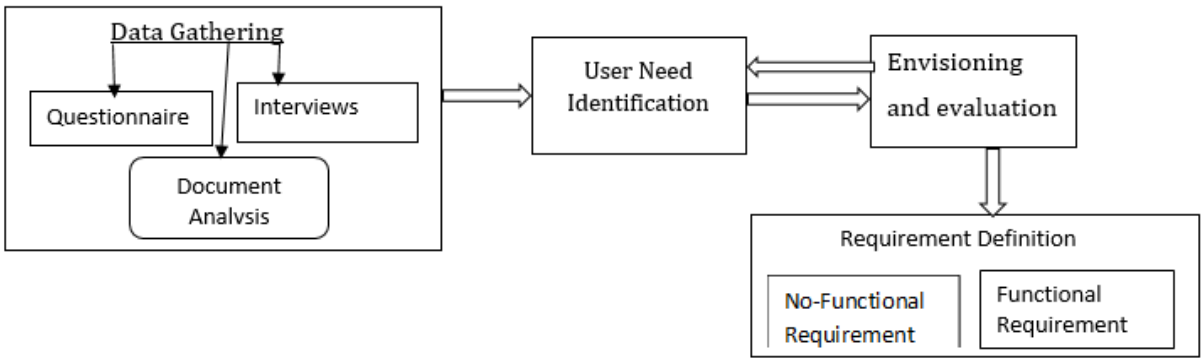



Figure 3.2 Requirement specification diagram

In the previous sections, we described the data sources and techniques of data gathering .From that we have gather the requirements information from three higher education institution staff, ICT center employees and MOE.

After we analyzed the data, we grouped the requirements into functional requirements and nonfunctional requirements. The use case diagram were used to indicate the relations between use case, between actors and as well as between use case and actors.

### 3.7.1. Functional Requirements

According to the requirement analysis on the cloud based educational resources sharing, EHEI educational resource sharing system is partitioned into five functional modules: user management, application management, resource management, Resource sharing and Get resources. The general structure of the system functions is shown in Figure 3.3

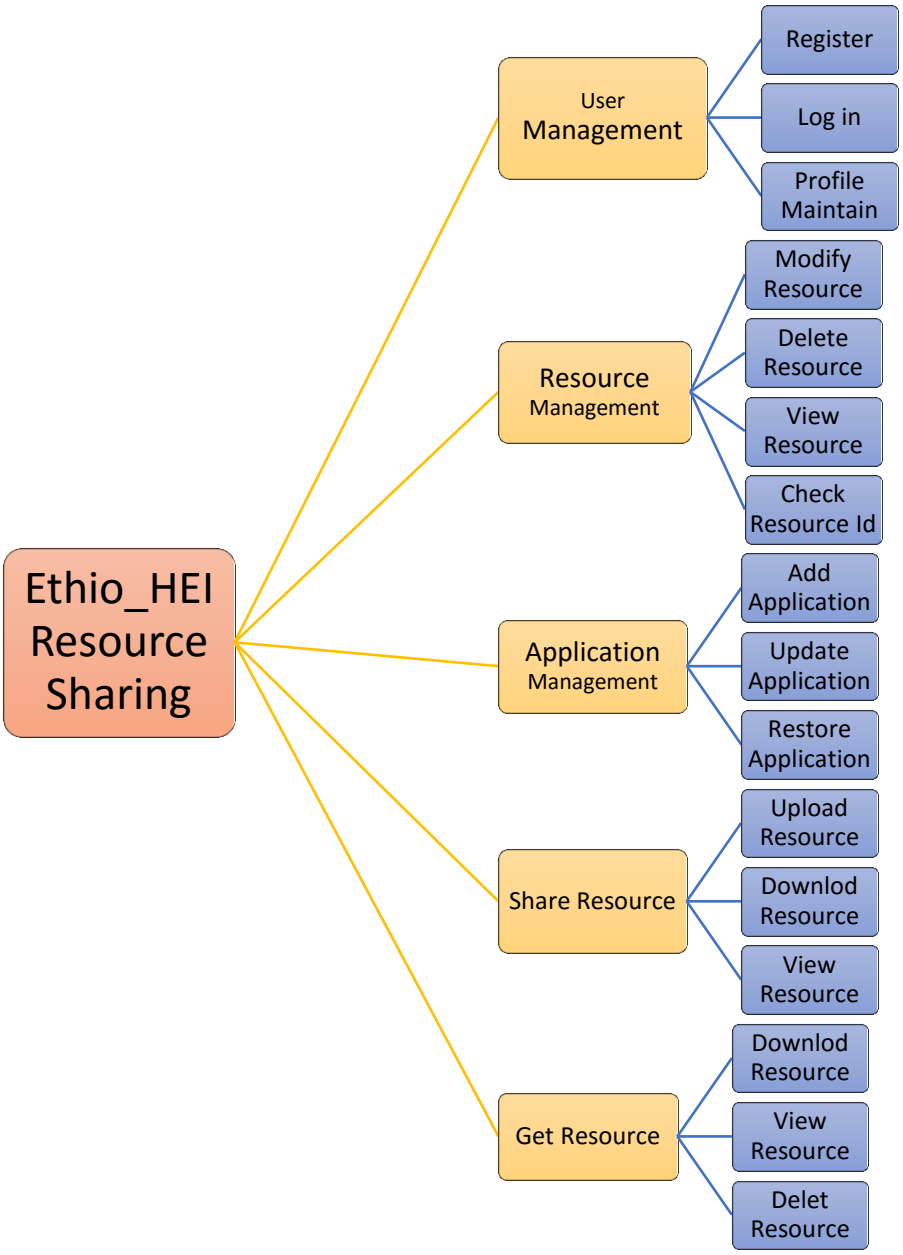



Figure 3.3 Functional Requirement

### 3.7.1.1. Use Case Diagram

Use case view defines what functions the system should provide, and describe what problems the system should help users to solve, i.e. who uses which case, in order to model system functions. This is also known as requirement modeling. The use case diagram consists of such model elements as system, Actors and use case; it also needs to specify the relations between elements, between Actors and Use case, as well as between actors and use case .The use case diagram of

the cloud based educational resource sharing is mainly responsible for describing the relation between actor and case. In the system, there are four actors: student, instructor, local admin and central admin, each of which has their own case. The use case view of the proposed system is shown in Figure 3.4 Use case Diagram

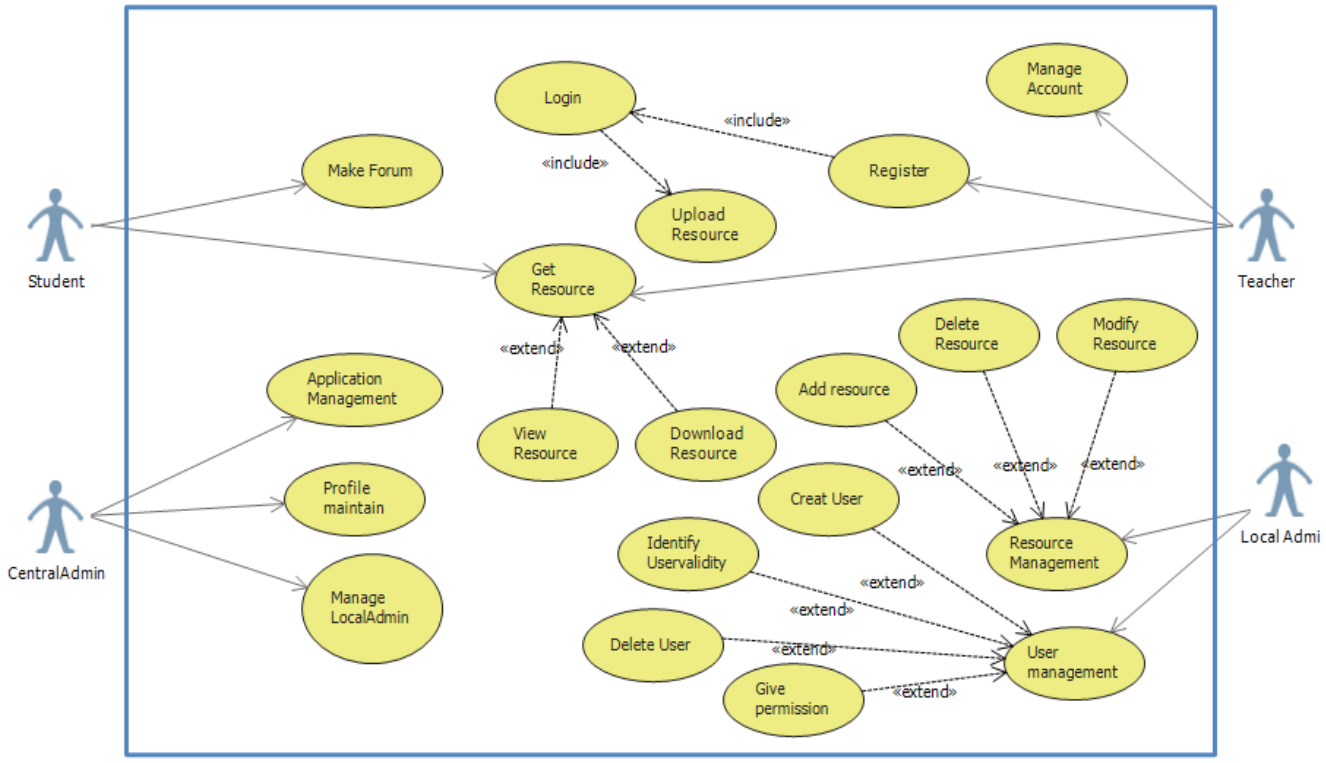



Figure 3.4 Use case Diagram

### 3.7.1.2. Use case Diagram Description

The cloud based educational resource sharing prototype system is designed for four types of users: students, Instructor, local admin, and central admin. Their business requirements are described below:

- For students: they can download and view educational resources on the cloud based educational resource sharing system page. Students are also allowed to visit the history page of the educational resource sharing system.

- For Instructor: they can log in into the cloud based educational resource sharing system .once they logged into the system, they can upload documents, edit document, delete document add document types and university. They can also download documents.
- Localadmin: they can login into the system as a local administrator and manage the local server. By using resource management module managing courses, the Localadmin can create, update and delete resource as well as share resources within the platform.
- Centraladmin: By logging on the Ethio_HEI resource sharing system manage users and resources. By managing users, the central administrator can directly create, modify, delete or authorize common users.

### 3.7.1.3 Class Diagram

In Ethio_HEI resource sharing system, to enable users and administrators to analyze and use educational resources more easily, the same business data usually needs to be displayed in multiple views. For example, a table attributes can represent the message of the same application data object in different ways. So objects are transparent to each other, allowing users to separately reuse the table objects based on their needs. The objects can immediately represent the changes that users make to the information in the table. So to do this, the researcher used a MVC model to design the class diagram and also the model is applied in the implementation to making the program structure more clear and flexible. The three components of the MVC design mode, i.e. Model, View and Controller, correspond to internal data, data representation and input/output control. The role of MVC in the design of system object model for the proposed system is as follows:

(1)Model is a logic abstraction of problem-related data, represents internal properties of the object and is also the core of the entire model. It follows the object-oriented method, and abstracts the object in the problem into the application object. These abstracted objects encapsulate the properties of the objects and the logics hidden in them. Hence, in the proposed system, the object properties and methods encapsulated in each functional module fully represent the component of Model. The design of object models (e.g. Document class, User class and University class) is the design of Model.

(2) View is the visual representation of the model. A model can correspond to one or more views. It can be classified into student view, instructor view and administrator view, according to

the types of users. View is capable of interacting with the outside world and serves as the interface between the application system and the outside world. On the one hand, it provides the outside world with input means and invokes application logics. On the other hand, it displays the results of application logics to the outside world. Hence, the subclasses (e.g. student, instructor and admin) derived from the user class in the proposed system forms the foundation for the implementation of the design mode where more than one view corresponds to the same model.

(3)Controller is the link between model and view. It extracts the outside information sent by view, transforms the interaction between user and view into the application behavior-based standard business events, and then interprets the standard business events into the actions that should be followed by model (e.g. activating business logics or modifying the status of model).Meanwhile, controller informs view of model update and modifications to guarantee consistency of each view with model. In the proposed system, this is mainly represented by the design of the Action class. Request action in the page corresponds to Action. Both setter and getter are responsible for processing and storing data or status, executing business logics, and returning processing results to users. Basic contents of the Action class are follows:

- Provide basic properties as well as the getter and setter methods of the properties. Basic properties include request parameters and their corresponding information.
- Provide a default Action processing method, i.e. public String execute (), which can be used to process business logics and return the string obtained by processing characters.
- Provide other Action processing methods.

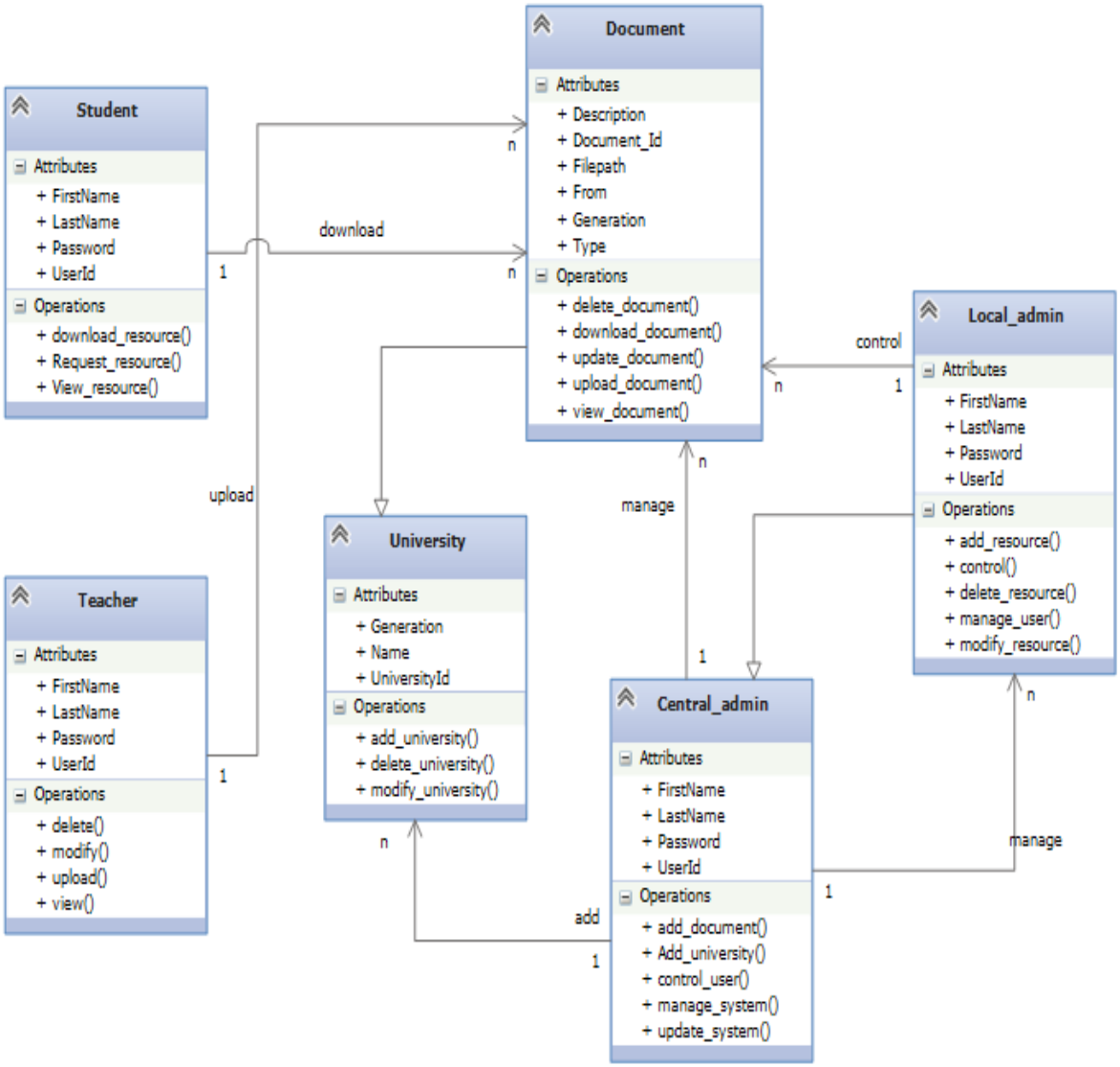



Figure 3.5. System Class Diagram

### 3.7.1.4. Sequence diagram

In previous subsection, major classes are discussed and here to further specify how the system implements use case via object interaction, this subsection will display major functional sequence diagrams. The interaction between different user classes and system function classes is used as an example for illustration.

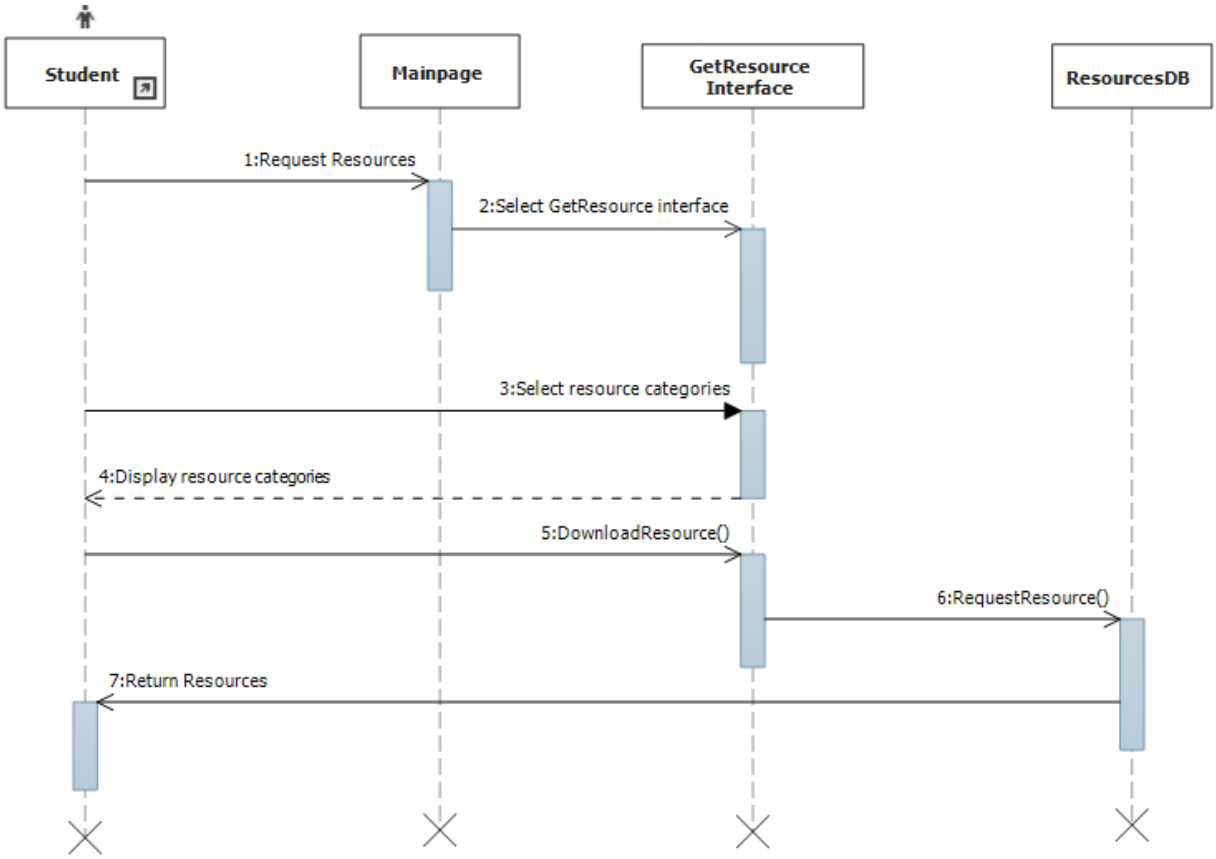



Figure 3.6 Sequence Diagram of Student Viewing resources Information and Downloading

We can see from the above diagram that the user class first applies to request the resources. After the system decides that the corresponding role and permission are in line with the requirements, it will return to the resource pages from document class; Then after the user click to download the resource, the document class will invoke Request resource () method to find out the corresponding resources information in the database, and return the download link to the user class. In this way, the resource information querying and downloading is completed, thus realizing the interaction between the user class and the resource class.

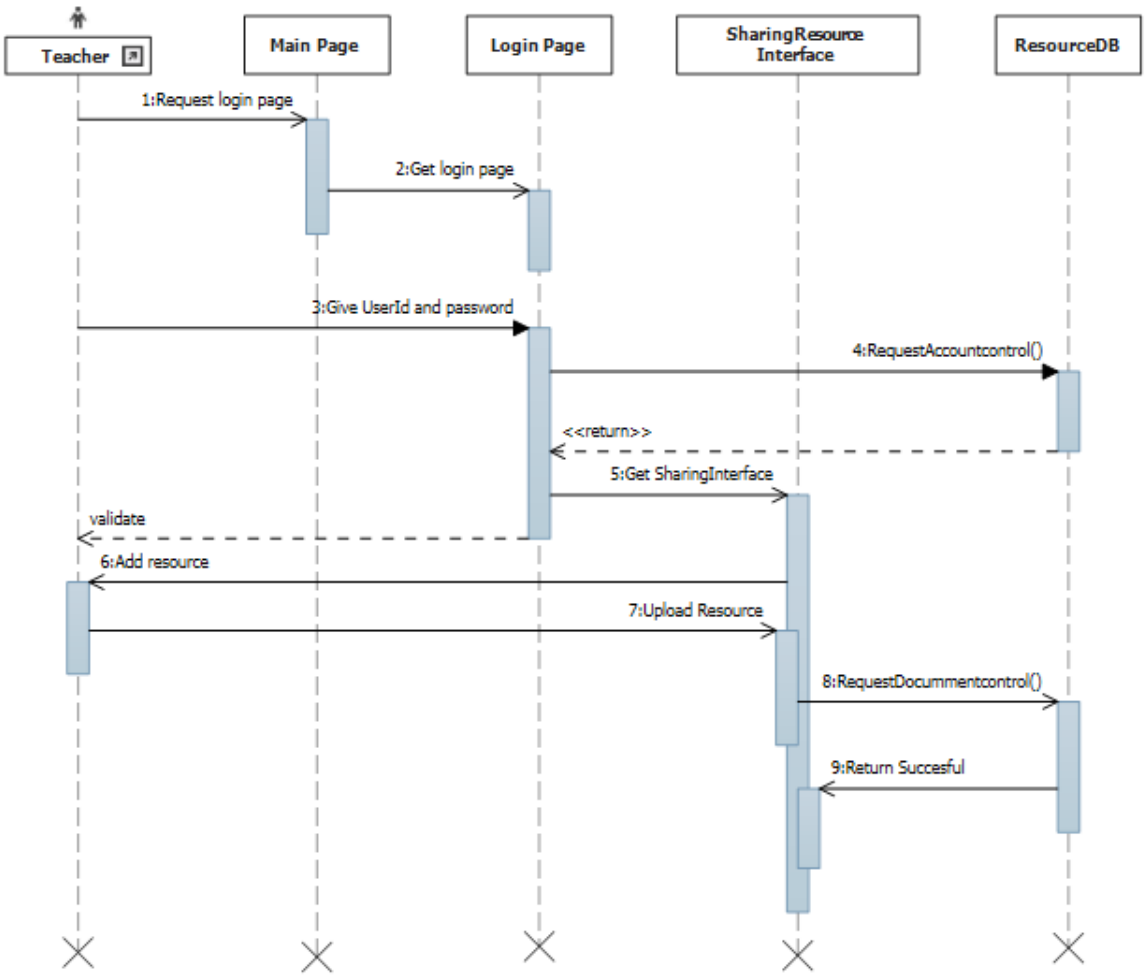



Figure 3.7 Sequence Diagram of Instructor Uploading Resource

The above figure shows the interaction between Instructor class and document class. As shown in the figure, Instructor class sends Request to Main Page to apply for login page to Sharing page. After the system approves the user role and permission, it will immediately return the resource uploading form page to the browser of the front-end users. Then, after the teacher class selects the uploading resource () method and, a new record of resource will be added to the database by the Documentcontrol () method after the database is updated successfully, the system will return a message to the SharingResource page.

### 3.7.2 Non-functional Requirements

(1) System structure: MVC design mode, Visual Studio development environment under .Net framework and window azure SDK and SQL Server management studio 2014 as the background database.

(2) Performance requirements:

- Response time: during interaction between each of the subsystem and users, the system must promptly respond to each user application, ensuring that the response time is no more than 0.5s.
- System reliability and stability: the system needs to ensure its reliability, stability and data security in the case of high concurrency.
- Ease of use of the system: the system should encapsulate complex operations as many as possible, enabling users to operate easily and with express purposes.
- System scalability: the system should be highly cohesive and loosely coupled so that it can be easily extended to accommodate future changes and needs of the cloud platform.

(3) Failure processing requirements: The system should support prevention of wrong data entry by notifying of the user about the possible error. Error logs can be created to help quickly locate the errors.

(4) Operation requirements: the system can be operated in ways Windows operating mode, Android Operating mode and IOS mode in order to facilitate friendly interaction with users. And also the system can be operated in any internet enabling devices like desktop, laptop, tablet and smartphones.

# Chapter Four: Cloud Platform Selection and Designing a Proposed Architecture

## 4.1. Cloud Platform Selection

In chapter two, we have discussed the three cloud computing service delivery models. In this study platform as a service (PaaS) cloud service delivery model has been selected.Beacuse, for the proposed architecture, a prototype application has been developed for the purpose of validating the architecture on a public cloud development model. So to develop the prototype application and deploy the application, also have used platform as a service which are used for web application development and hosting.

PaaS is used to develop web and mobile applications using components that are pre-configured and maintained by the service provider, including programming languages, application servers and databases. According to the requirement and characteristic of the cloud education, we choose the PaaS layer as the basic service model which has a relative complementary between the control and security. In this level, the user has the ability to develop and deploy the custom applications to the cloud platform.

There are a lot of tools available for the application developers in the cloud environment and we try to describe the most popular platform providers and their development and hosting tools .To select the best fit platform as a service tool ,we have gone through identified around fifteen tools. But due to software compatibility, license agreement, price and poor feature factor, we rejected eleven tools and we have done comparison and analysis on the four tools only, which are Microsoft Windows Azure (MWA), Google App Engine (GAE), Red hat Openshift and Manjrasoft Aneka.

### 4.1.1. Microsoft Window Azure

Windows Azure is an open and flexible cloud platform that enables to quickly build, deploy, and manage applications across a global network of Microsoft-managed datacenters.
We can build applications using any language, tool, or framework. And we can integrate public cloud applications with the existing IT environment.

This definition tells us that Windows Azure is a cloud platform, which means we can use it for running your business applications, services, and workloads in the cloud. But it also includes some key words that tell us even more:

- **Open** Windows Azure provides a set of cloud services that allow you to build and deploy cloud-based applications using almost any programming language, framework or tool.
- **Flexible** Windows Azure provides a wide range of cloud services that can let us do everything from hosting website, web apps to running big SQL databases in the cloud. It also includes different features that can help deliver high performance and low latency for cloud-based applications.
- **Microsoft-managed** Windows Azure services are currently hosted in several datacenters spread across the United States, Europe, and Asia. These datacenters are managed by Microsoft and provide expert global support on a 24x7x365 basis.
- **Compatible** Cloud applications running on Windows Azure can easily be integrated with on-premises IT environments that utilize the Microsoft Windows Server platform.

So with Windows Azure platform [36] provides friendly interfaces to deal with the heart of PaaS in developing and deploying different .NET applications start from very simple Hello World applications to distributed relational databases. One of Windows Azure's services is SQL Azure, which presents DB services from building the DB to deploy it and scale it through Microsoft data centers. SQL Azure includes relational database services, such as reporting, querying, and data synchronizing. Windows Azure offers several features including computing resources, storage, database, Virtual Machines (VMs), access control, Content Delivery Network (CDN), caching, virtual network, service bus, business intelligence, and market place.. Windows Azure provides a platform service which includes operating systems, a set of developer tools, and different levels on network controls to develop, host, scale, and manage developed applications on web and non-web environments [30].

In addition, the Windows Azure platform offers prebuilt sub-programs which often represent reuse functionalities to save the developers' time and let them focus more on their projects. By using Windows Azure, the institutes and universities do not need special equipment or infrastructure; all they need is Internet connection.

### 4.1.2. Red Hat Openshift

Red Hat Openshift is based on open source applications and offers a wide variety of languages, databases and components.The PaaS is highly customizable and offered in three forms:Openshift Online (a cloud-based hosting service), Openshift Enterprise (a private PaaS that runs in your data center) and Openshift Origin (the open source application hosting platform).Openshift automates system administration tasks such as virtual server provisioning, configuration and scaling and supports git repositories for code management.

### 4.1.3. Manjrasoft Aneka

Aneka is a platform for deploying Clouds developing applications on top of it. It provides a runtime environment and a set of APIs that allow developers to build .NET applications that leverage their computation on either public or private clouds. One of the key features of Aneka is the ability of supporting multiple programming models that are ways of expressing the execution logic of applications by using specific abstractions[36]. This is accomplished by creating a customizable and extensible service oriented runtime environment represented by a collection of software containers connected together. By leveraging on these architecture advanced services including resource reservation, persistence, storage management, security, and performance monitoring have been implemented. On top of this infrastructure different programming models can be plugged to provide support for different scenarios as demonstrated by the engineering, life science, and industry applications.

### 4.1.4. Google App Engine

Google App Engine is designed for distributed web applications and developers using Java, Python, PHP and Go. The Java environment supports other languages that make use of the JRE and there is a SDK for each of the four main supported languages as well as a plugin for Eclipse. The PaaS offers managed infrastructure and runtime environments that are guaranteed to scale, but only if the applications fit the restrictions of Google App Engine. The Data store, a transactional, schema-less data store based on key-value pairs, handles the complex management of data that's accessible to multiple machine instances.

**Table 4.1: Comparison of the four service provider**

| Compare Factor | Manjrasoft Aneka | Google AppEngine | Microsoft Azure | Red Hat Openshift |
|---|---|---|---|---|
| User access interface | WebAPIs, Custom GUI | Limited GUI and Command line(Cf-cli) | Azure Web Portal and Custom GUI | WebAPIs, Custom GUI and command line interface |
| Language Support | .NET Frameworks language | Limited to Java ,python and PHP | Microsoft Visual Studio(.Net),Java,PHP ,C | Java EE, PHP, Ruby,MySQL, MONGODB |
| Platform(OS, Run time | .NET/Mono on Windows, Linux, MacOS | Linux, Windows | .NET on Windows | Linux, Windows Base |
| Scalability | Dynamic Scalability | Need codes to scale | Scalable based on bandwidth | Auto-Scaling |
| Reliability | Improved Reliability | Improved Reliability | Improved Reliability | Improved Reliability |
| Efficiency | Efficiently adopt cloud services by scheduling | Efficiently adopt cloud services in a scalable and automated way | Efficiently adopt services by identifying underutilized servers | Efficiently adopt cloud services by scheduling |
| Deployment Model | Customized web application(C# C++, VB,) | Deploying using BOSH directory | Azure Services, web deployment using IIS and using git hub | Customized Web application(Java,PHP,Node.js) |
| API | Sets of APIs | Limited APIs | More sets of APIs | Set of APIs |
| Availability | https://www.manjrasoft.com/products.html | https://www.GoogleAppengine.com | http://www.microsoft.com/azure/ | https://developers.openshift.com/ |

Through comparison, we choose the Microsoft Window Azure. It has wide variety of languages and databases that enables the developer to create easily their applications and more understandable. We can manage our code by using azure web portal; The main criteria to select Microsoft Azure is, it gives for the developer more deployment options than the other three platform and more sets of application program interface (API) .using Microsoft azure the developer can deploy locally using web deployment on IIS .Cloud applications running on Windows Azure can easily be integrated with on-premises IT environments that utilize the Microsoft Windows Server platform. The one and last criteria we chosen window azure is, Ethiopian ministry of education has took a contract in 2016 with Microsoft cloud academy ,these makes to create an opportunity for higher education institutions and learners to get a licensed platform in order to develop and host an application using an emerging technologies.

## 4.2. Designing the Proposed architecture

Due to different factors, it is true that ICT usage in Ethiopian Higher Education Institutions in its current situation is very primitive, as discussed in previous sections. Harnessing the Cloud Computing technology for delivering different services such as e-learning environment, Class Room Management Systems, Enterprise Resource Planning Systems, researching and similar services will give more flexibilities and dynamic resource utilization which solves the scalability issues. Then the Virtual University Services on top of Cloud Computing layer helps to solve limitations of the current IT service deployment scenario.

So In this study we proposed Cloud Education resources sharing architecture. To get layer and block firstly we analyzed Cloud taxonomy and we got classification related to Cloud Computing such as service type, middleware, and others. However we don't know what relationship between classifications; we reviewed existing cloud computing architecture such as cloud computing reference architecture, IBM cloud computing reference architecture, NIST cloud computing reference architecture and Microsoft cloud academy reference architecture.

### 4.2.1. Design Requirements of CBAERS.

These are the functional requirements of the educational resource sharing system which are related to functional aspect of the system. As a result, they define functions and functionality within and from the prototype system.

- It should register higher education students, staffs and other users.
- It should support educational resource sharing based on cloud computing.
- It should be assign roles to the users.
- It should accessible and implementable in the existing ICT infrastructure learning environment.
- It should create collaboration among higher education institutions and higher education community.
- It should support sharing of experience electronically which include best practices, challenges and their solutions, professional ethics, problem solving mechanisms etc.
- It should support uploading, downloading and viewing of educational resources.
- It should support searching of the available educational resources.
- It should support the parameters of IBM Cloud Computing Reference Architecture (CCRA) 3.

### 4.2.2 Conceptual Architecture of Cloud Based Educational Resources Sharing

Cloud computing solution saves us from having to purchase, maintain and train IT staff on expensive hardware and proprietary software code. With One Network's technology solutions in the cloud, we no longer have to purchase, maintain, update and replace expensive resources. The cloud solution also enables us to provide industry-leading time to-value, with implementation times averaging less than half the time of traditional supply chain solutions. In addition, real-time data across all of your value chain participants means increased revenue opportunities. This conceptual architectures specifies the virtualization technology to be used to build a cloud based educational resources sharing above the hybrid cloud infrastructure in order to use the resources everywhere, anytime and using any devices and also to use resources more effectively and to support the QoS (Quality of Service) objectives such as high availability, performance, reliability, scalability, load balancing and security in the service models (IaaS, PaaS, SaaS) of the

cloud. Based on the roadmap for the successful adoption of cloud based educational resources sharing, the researcher proposed Conceptual architecture for Cloud based educational resources sharing system. Figure 4.2 show the Cloud based Educational resources sharing Architecture for Ethiopia HEIs. The Proposed conceptual Architecture consists of primarily of four User Interface, SaaS, PaaS, and IaaS) and two vertical layers (Service Management and Integration and System Security Layers).

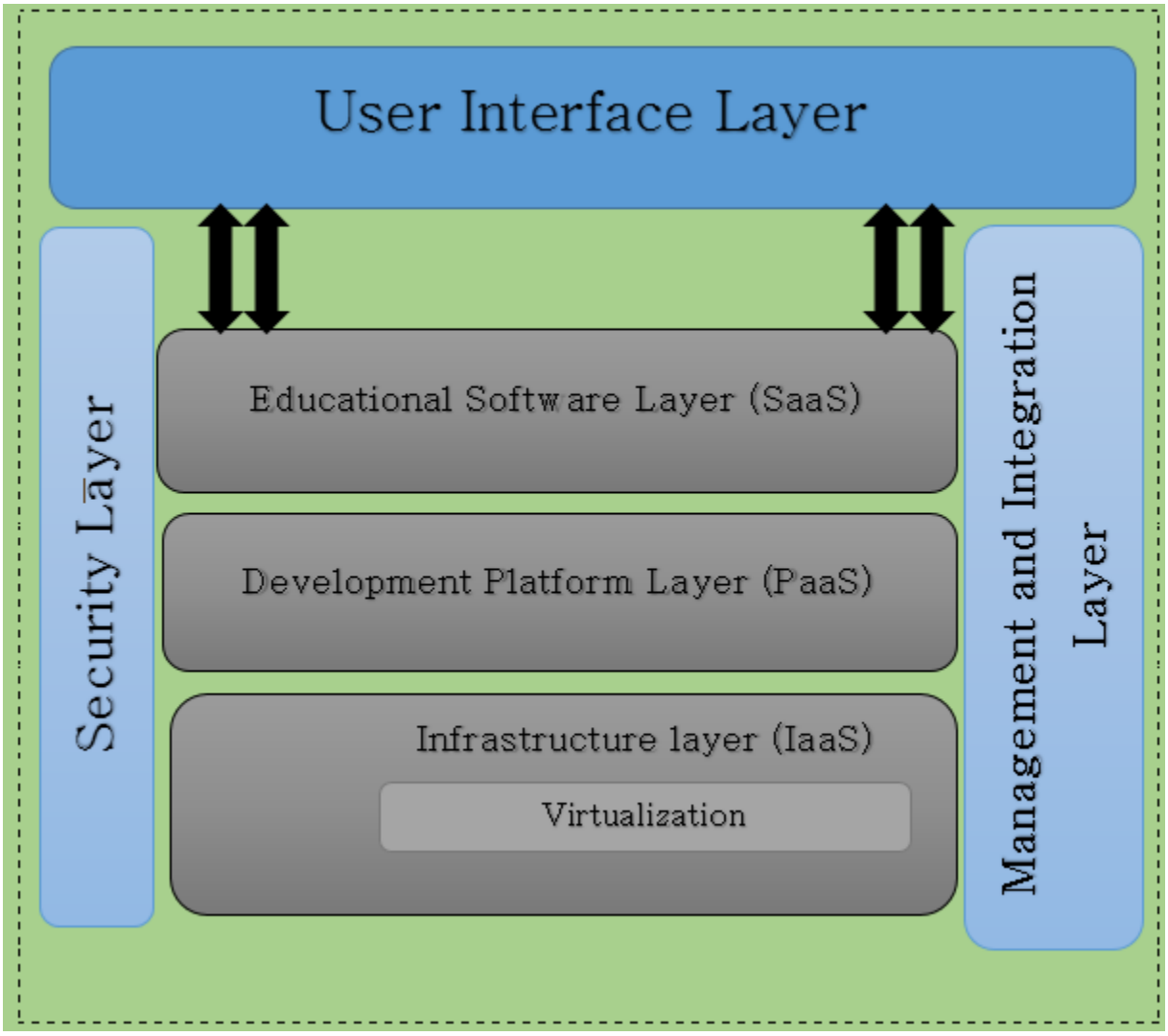



Figure 4.1Ethio_HEI educational resource sharing conceptual architecture

**i. User Interface Layer**

The user interface is simple, user-friendly and easily understandable, without much graphics and drawings. It will reduce the amount of memory required by the application and reduces the time

of development. The original version would be designed with interactive and user-friendly icons and menus. The end-users communicate with the cloud based educational resource sharing system using the browser enabled devices by means of the protocols (like http, https).

**ii. Educational Software Layer (SaaS**)

AS SaaS is what most non-IT users will see and consume: Software as a Service (SaaS). At the SaaS level, service providers offer consumer or industrial applications directly to individual users and enterprise users. At this level, the following technologies are involved: Web 2.0, Java Server Page (JSP), C#, ASP.Net, Microsoft SQL server 2014, Mashup, SOA and multi-tenancy. The development of AJAX technology of Web 2.0 makes Web application easier to use, and brings user experience of desktop application to Web users, which in Cloud Computing Technologies and Applications turn make people adapt to the transfer from desktop application to Web application easily. Mashup technology provide a capability of assembling contents on Web, which can allow users to customize websites freely and aggregate contents from different websites, and enables developers to build application quickly. Similarly, SOA provides combination and integration function as well, but it provides the function in the background of Web. Multi-tenancy is a technology that supports multi tenancies and customers in the same operating environment. It can significantly reduce resource consumptions and cost for every customer.

Education Software as a service for users to manage interactions with Cloud Services in HEIs. Cloud application layer deliver software as a service over the Internet, eliminating the need to install and run the application on the customer's own computers and simplifying maintenance and support. This layer provides the SaaS to the end-users of the university. The educational resource sharing software using web2.0 tools or above and other licensed third-party software are installed in the HEIs cloud and these are provided to the users as a service. Apart from this, it provides various customization options to the end-users using the protocols such as REST, SOAP etc.

### iii. Education Development Platform Layer (PaaS)

Cloud platform services deliver a computing platform and/or solution stack as a service, often consuming cloud infrastructure and sustaining cloud applications. It facilitates deployment of applications without the cost and complexity of buying and managing the underlying hardware and software layers. The Platform Layer adds on a collection of specialized tools, middleware and services on top of the unified resources to provide a development and/or deployment platform. Platform as a Service (PaaS) offers a high-level integrated environment to build, test, and deploy custom applications.

At the PaaS level, what the service provider's offer is packaged IT capability, or some logical resources, such as databases, file systems, and application operating environment. Currently, actual cases in the industry include Rational Developer Cloud of IBM, Azure of Microsoft and AppEngine of Google. At this level, two core technologies are involved. The first is software development, testing and running based on cloud. PaaS service is software developer oriented. It used to be a huge difficulty for developers to write programs via network in a distributed computing environment, and now due to the improvement of network bandwidth, two technologies can solve this problem: the first is online development tools. Developers can directly complete remote development and application through browser and remote console (development tools run in the console) technologies without local installation of development tools. Another is integration technology of local development tools and cloud computing, which means to deploy the developed application directly into cloud computing environment through local development tools. The second core technology is large-scale distributed application operating environment. It refers to scalable application middleware, database and file system built with large amount of servers. This application operating environment enables application to make full use of abundant computing and storage resource in cloud computing center to achieve full extension, go beyond the resource limitation of single physical hardware, and meet the access requirements of millions of Internet users.

**Iv. Infrastructure Layer (IaaS)**

IaaS comprised of the physical assets we can see and touch: servers, storage, and networking switches. At the IaaS level, what cloud computing service provider can offer is basic computing and storage capability. Infrastructure as a Service (IaaS) provisions hardware, software, and equipment's to deliver software application environments with a resource usage-based pricing model.

- Physical Sub-layer: It mainly supports the basic environment, including computers, storage, network interconnect devices, and database resources.

- Virtual Resources Sub-layer: Using virtualization technology, IT resources are combined into resource pools: the computing, data, network, storage resource pool. Thus a large number of the same type of IT resource is configured into graph isomorphism or near graph isomorphism, providing high performance services. So using virtualization technology, we could provide as little as 0.1 CPU in a virtual machine to the end user, therefore drastically increasing the utilization potential of a physical server to multiple users.

**v. Service Management and Integration Layer**

The Management and Integration layer is used to automate the flow of filtered data and information between the horizontal layers. It ensures that processed outputs from one layer to another are contextually related and syntactically correct. It also a management layer that leverages automation and functions across physical, virtual, and application resources is another required layer for higher IT maturity.

The cloud integration is the ability to deliver a complete integration stack from the cloud, including interfacing with applications, semantic mediation, flow control, integration design, etc.

**Vi. System Security Layer**

The Security layer ensures the necessary authentication, authorization and auditing for the use of data and services by legitimate users. Further, it ensures secure personalization of end users services based on pre-defined preferences for processing and retrieval of contextual information from a Cloud environment. Each service layer has different levels of security requirement in the cloud based educational resource sharing environment.

### 4.2.3 Architecture for Delivering Educational Resource Sharing Services through Cloud

This architecture for delivering educational resource sharing services through Cloud based architecture to implement in HEIs.The proposed architecture for educational resource sharing is given in Figure 4.2. The four layers architecture distributing the service platforms.

#### I. User Layer

In the educational resource sharing ecosystem, three user's roles can be notice: student, teacher and Administrator. When implementing cloud based educational resource sharing services it is important to clear define scope of each user role in terms of access right and set of available features. This user layer mainly responsible for checking the track of the authorizations users and its access mode which is selected in the User Interface layer checked them via this module. Users' information is stored in the Users Logs module.

#### II. Devices layer

The end-users communicate with the cloud based educational resource sharing using the browser enabled devices such as (handheld computers, notebooks, net-books, ultra-books, tablets and mobile phones) by means of the protocols such as RDP, SSH, Http/Https and LDAP.

#### III. Connection Layer

In order to use cloud computing services, a device has to ensure secure and reliable network connection. Considering availability, GSM network are the most often used network connection technology in Ethiopia context and also (3G and 4G) and wired network connection technology also possible to enable access the services. In terms of reliability, Network bandwidth and latency for Mobile device connection to Internet, best way is using Wi-Fi orWiMax connection.

#### IV. Cloud services Layer

Cloud that hosts educational resource sharing services can be implemented in hybrid cloud infrastructure in order to use the resources more effectively and also to support the QoS (Quality of Service) objectives such as high availability, performance, reliability, scalability, load balancing and security in the service models. Considering service models (SaaS, PaaS and IaaS) of cloud computing, SaaS is the most appropriate. Educational resource sharing applications are

provided to the users of educational resource sharing system by using user registration and direct accessing the web application.

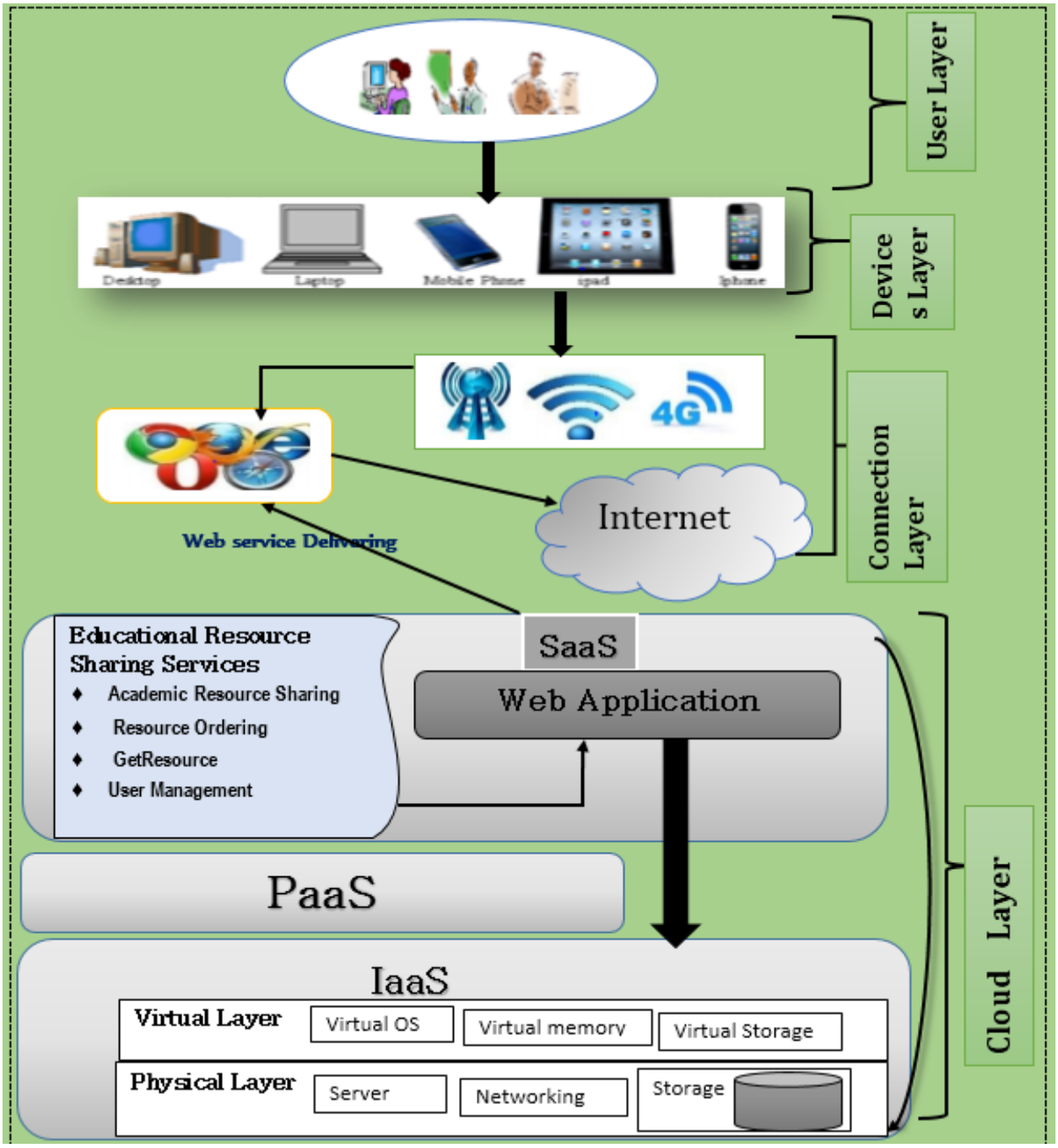



Figure 4.2 Ethio_HEI educational resource service delivering architecture (Own Work)

Based on the identified services and selected Cloud platforms, the researcher proposed Cloud Computing architectures for educational sharing resources that apply only in Ethiopian public university.

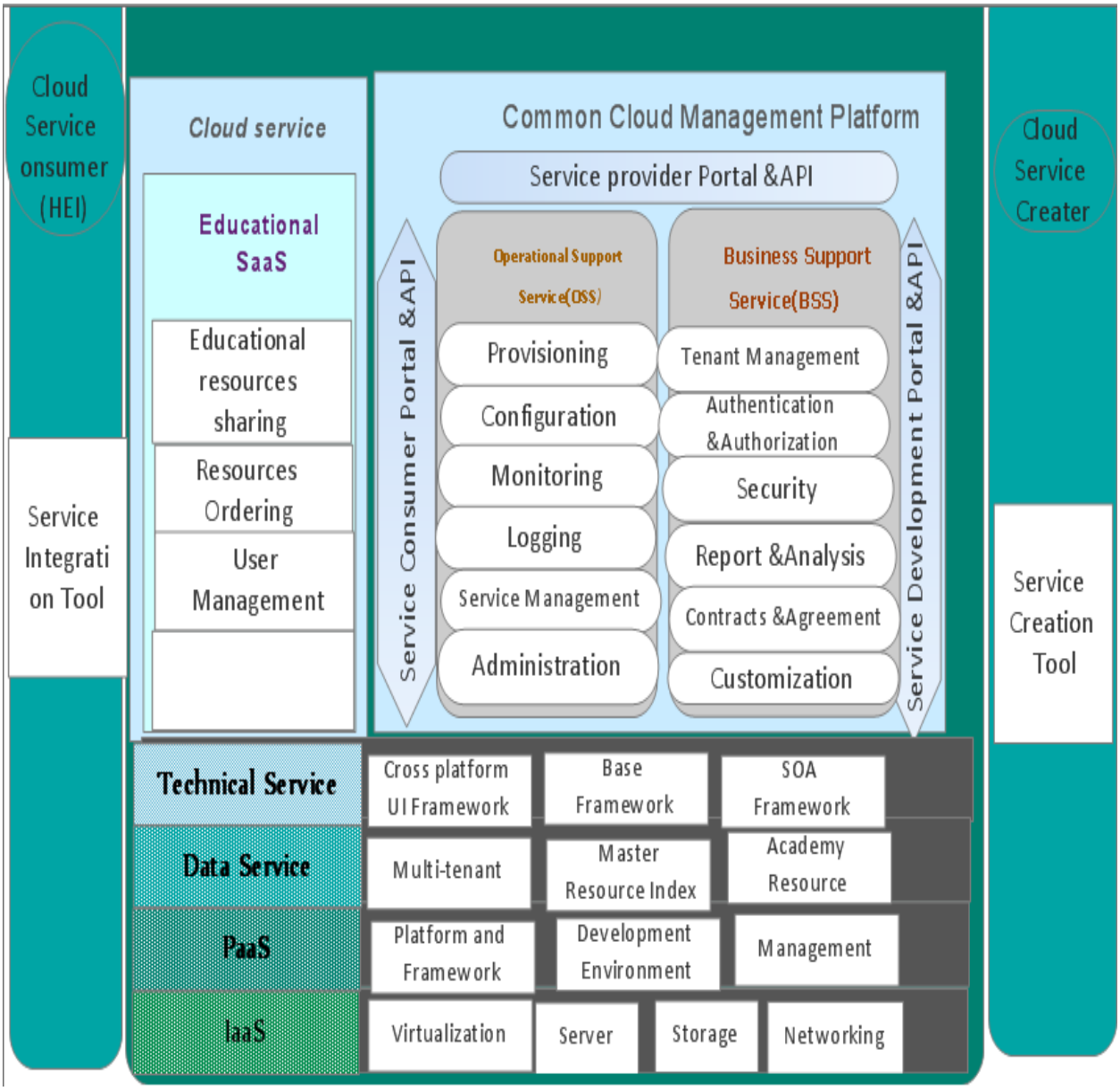



Figure 4.3.General Functionality and parameters of CBAERS (Adopted from [44])

The above architecture drawn by the relations between services layers and roles of the user in the cloud services.

• Roles: The main actors that communicate with the cloud service.as the above architecture shown that the roles group as Cloud service consumer, Cloud service provider and cloud service Creater.But in the prototype system implementation the researcher consider the roles as a student, instructor and administration roles. Each role has its own privilege to access the services and its own module to use the system.

• Activities: Those actions and capabilities that connect a role to a service.in this study the activities user management module, resource sharing module and get resource module.

• Layers: A classification of similar services based on finding commonalities. For example, based on the technology stack a service can be classified into infrastructure, middleware, application, and business process service

The most noticeable element in this architecture is the Cloud Computing Management Platform (CCMP) [37]. The CCMP provides a set of business support services (BSS) and operational support services (OSS) management services. CCMP services facilitate the communication between the different roles and the provider's underlying services (i.e., Infrastructure, Platform, Software and Business Process as a Service), through well-defined interfaces (APIs) For example, the OSS are managed operational services (i.e., provisioning, monitoring, and automation management services) that can be used by cloud service consumers to manage the cloud environment, by the cloud service provider to manage the infrastructure, and by the cloud service creators to create new services. Similarly, BSS are managed business services (i.e., billing, pricing, metering services), which are required by cloud service creators to implement a cloud service.

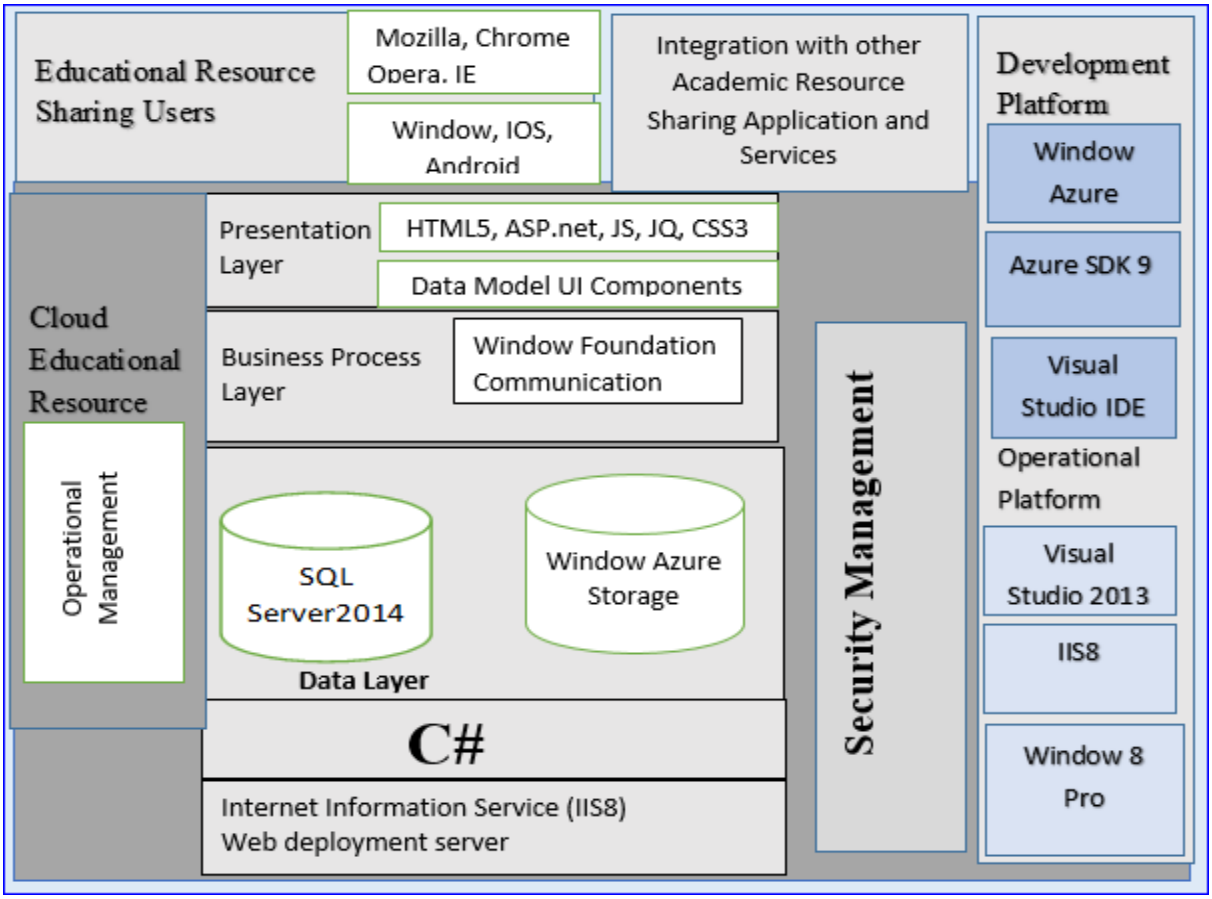



Figure 4.4 Development Overview of CBAERS (Own Work).

Figure 4.4. Illustrates development view of the proposed architecture. In the CBAERS, the educational users can access the system using different operating systems and web browsers. The UI of cloud based Cloud based educational resource sharing system was created using HTML, CSS, JS, ASP.net and C# as a main language, we have considered window foundation communication business process management. The integration of this CBERS system with other academic service system can be operated using JSON or other programing technologies. For the purpose of managing and storing the educational resources, we have used SQL database, azure storage service, and ASP.net web content management and IIS8 server. The development platform is Window azure.

# Chapter Five: Implementation

## 5.1 .Introduction

In this part, we will explain how to develop the Ethio_HEI resources sharing web application and explain how the architecture is to be implemented**.** In this thesis we apply MVC mode, to design the core class of the system, extract classes for the use case, to identify the relationship among the classes and to make the program structure more clear and flexible. Window azure cloud platform selected as the deployment and building application platform, window SQL azure as the storage database as the data storage. Then the rest part of this chapter will introduce each step of the development process.

## 5.2. Development Environment and Tools

The development environment for the Ethio_HEI resource sharing cloud based web application is configured as follows:

- Window azure platform(Platform as a Service)
- Window azure SDK v2.9
- Internet information service (IIS8)
- Visual Studio IDE 2013
- SQL Management Studio 2014

## 5.3. The Developed System Function

Based on the design architecture defined in previous chapter, a demo web-application developed aiming to the Ethio_HEI resource sharing system to display how the architecture can be used and work in the real world application .Based on the collected data analysis output the system's functions mainly divided into five categories: user management, resource management, Application management, Sharing resource and get resource. Under User management function: there is user registration, user loging, user roles assignation and user authentication and authorization sub function. Under resource management function: there is resource update, resource delete and add resource type sub function. Under sharing resource function: there is upload resource and edit resource function. Under get resource function: there is download resource and view resource sub function.

So access the web application, the user must use the web address of the application (Ethio_HEIResourcesSharing.com) and then we must login by our account username and password on the web application.

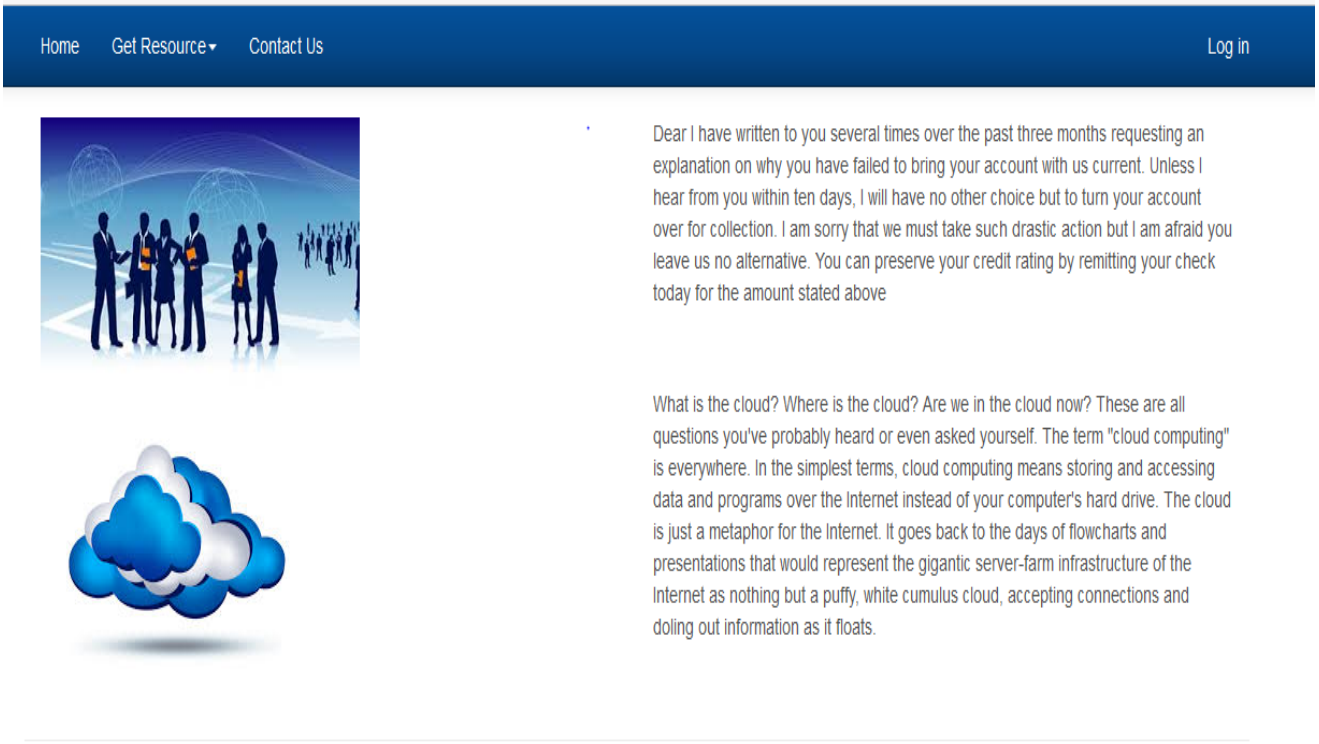



Figure 5.1 Ethio_HEIResourceSharing desktop interfaces Home Page

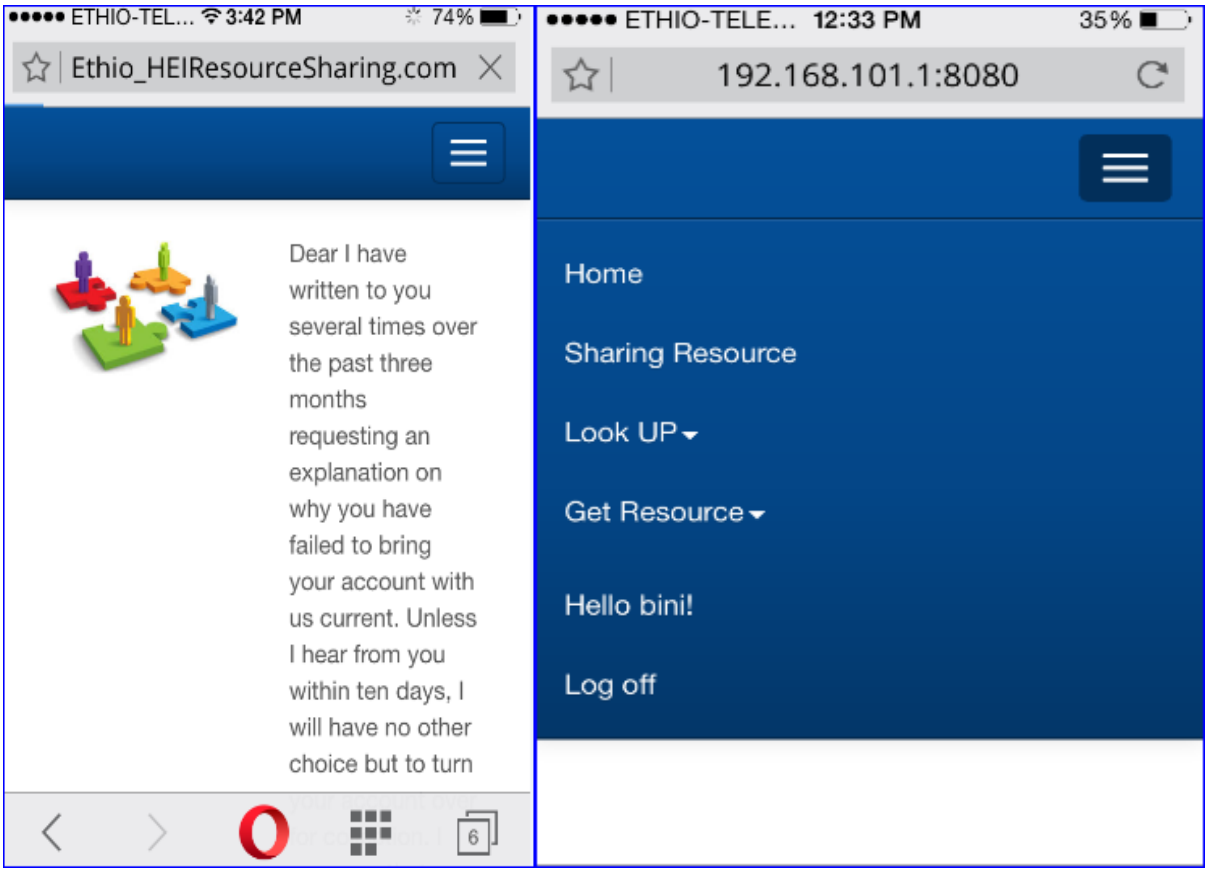



Figure 5.2 Ethio_HEIResourceSharing mobile interface Home Page and login page

The user register into the web application through the admin page and the admin can register the new user. The following figure shows the user registration page.

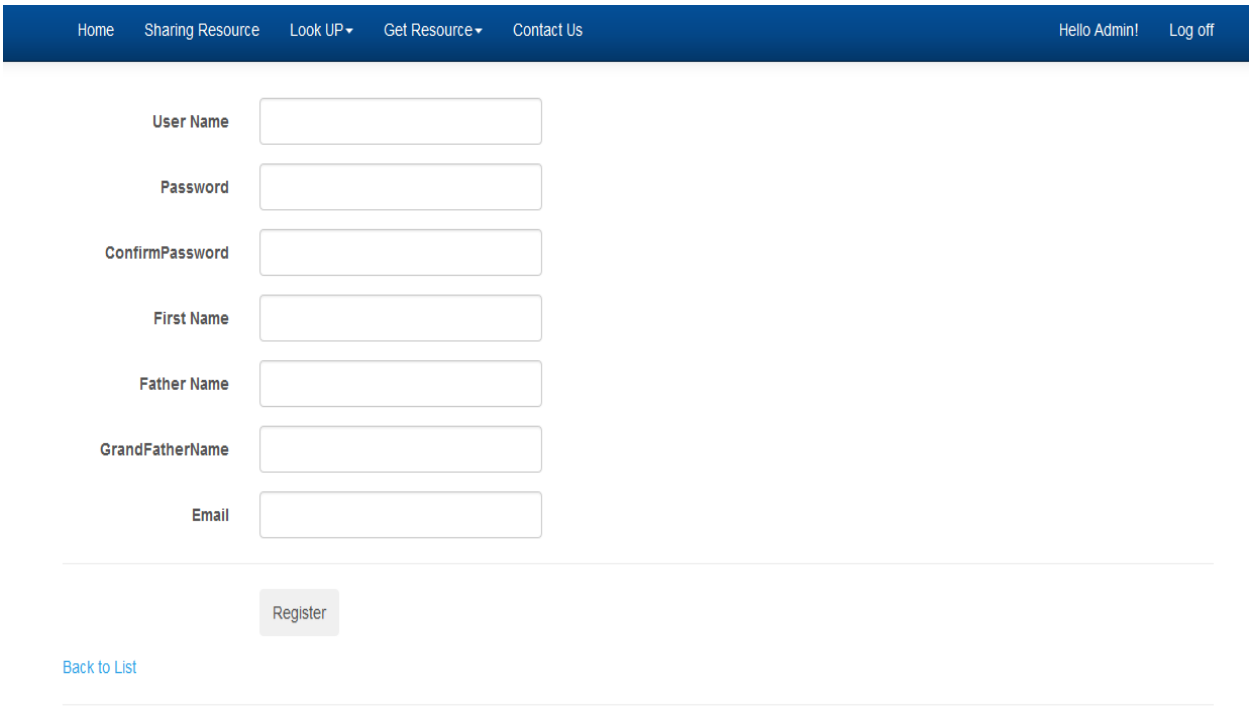



Figure 5.3 User Registration page

The admin can add resource file type, university, manage user (create new user, edit user, delete user and assign user roles and also the admin upload resource. The following figure shows admin user management page.

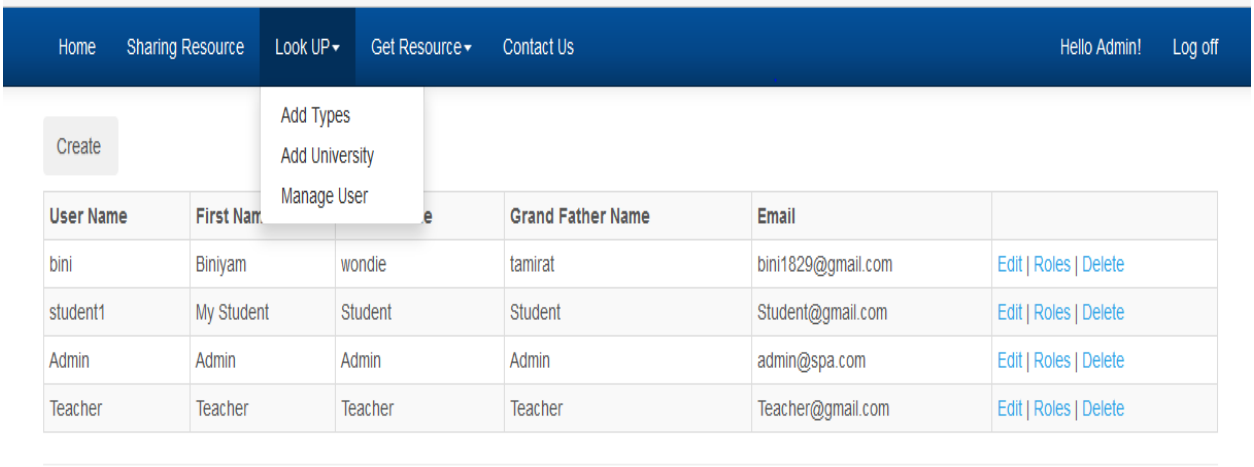



Figure 5.4 Admin user management page

Admin and instructors can upload resource and they can edit, view and download resource. The following figure shows resource uploading page.

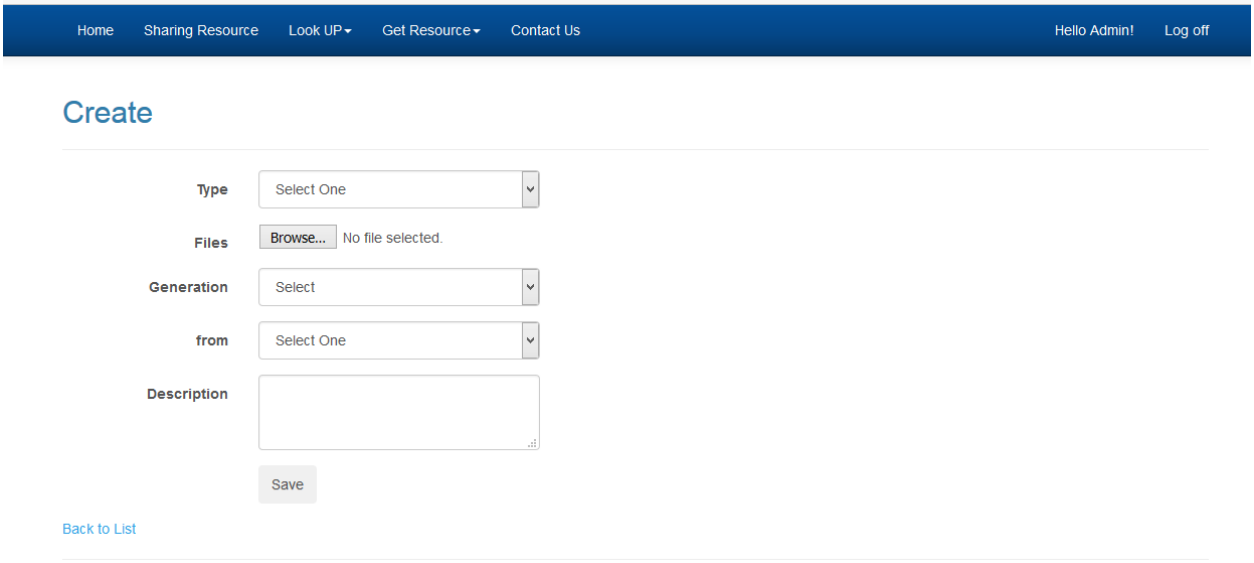



Figure 5.5 Resource Uploading Page

# Chapter Six: System Testing and Validation of Results

## 6.1. Introduction

After implementation is completed testing and evaluation is performed to make sure that the end users are satisfied and willing to accept the system .Under this chapter, we perform the system testing by using functional testing and evaluation is done by conducting a survey with the user. In this simulation test we use three devices such as: mobile phones, tablet, and computers. Server (IIS8) contains Educational resources sharing web application, database (App_data), the repository folder, and contents. Finally the testing results are analyzed and interpreted. In addition, the system has to be evaluated against the requirements to make sure that it satisfies what was expected from it.

## 6.2. Testing the Functionality of the System

In this section, the functionality of the prototype system is tested and verified whether the system has the expected functionality; whether user authentication and user authorization are correct; and whether the mechanism of error processing functions well etc. in this study we used black box approach because it focus on system functionality, easy to implement, and requires very little time compared to other techniques.

### 6.2.1. Testing user authentication

In this study the authentication mechanisms is based on role claims contained in the authentication token. This is often referred to as role-based access control (RBAC), and it may allow a more granular level of control over access to features and resources. If the user wants to login and enter an errors password or user name the system shows a message on the screen, indicates invalid username or password.

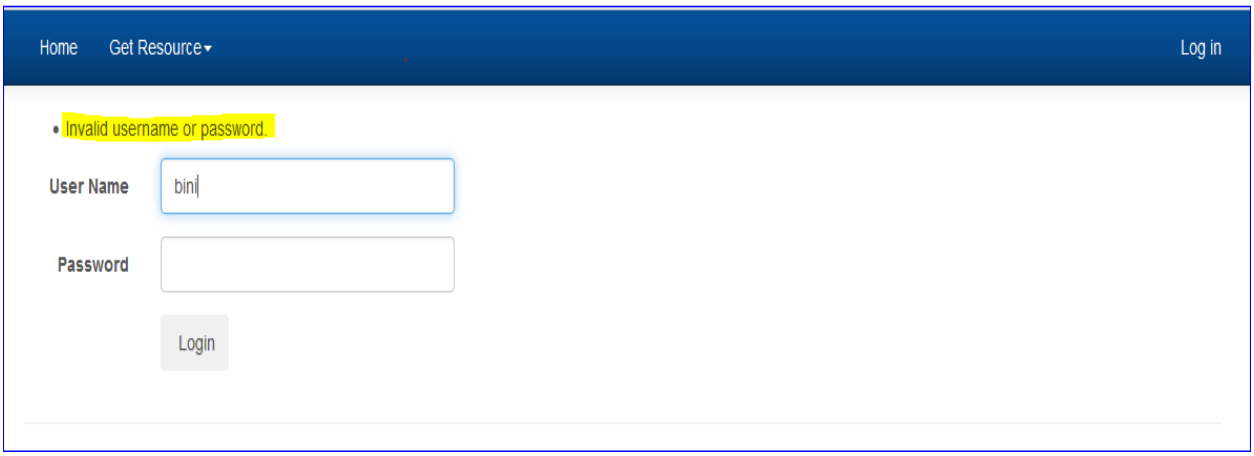



Figure 6.1 Login Testing

### 6.2.2. Testing user create

When the system Register a user that to create account ,all the information are fulfilled by Input all the information in the text box and scroll all Seek bars to a certain value and press the register button. Then a successful message shows on the screen, indicates register successfully. If Register a user without all the information fulfilled: that Input the information in one text box and press the register button ,an error message would be pop up on the screen that indicates registering data unsuccessfully. At below figure shows user registration that the user miss his user name, first name and father name field to fill and the system reject his registration, and display user name, first name and father name field is required.

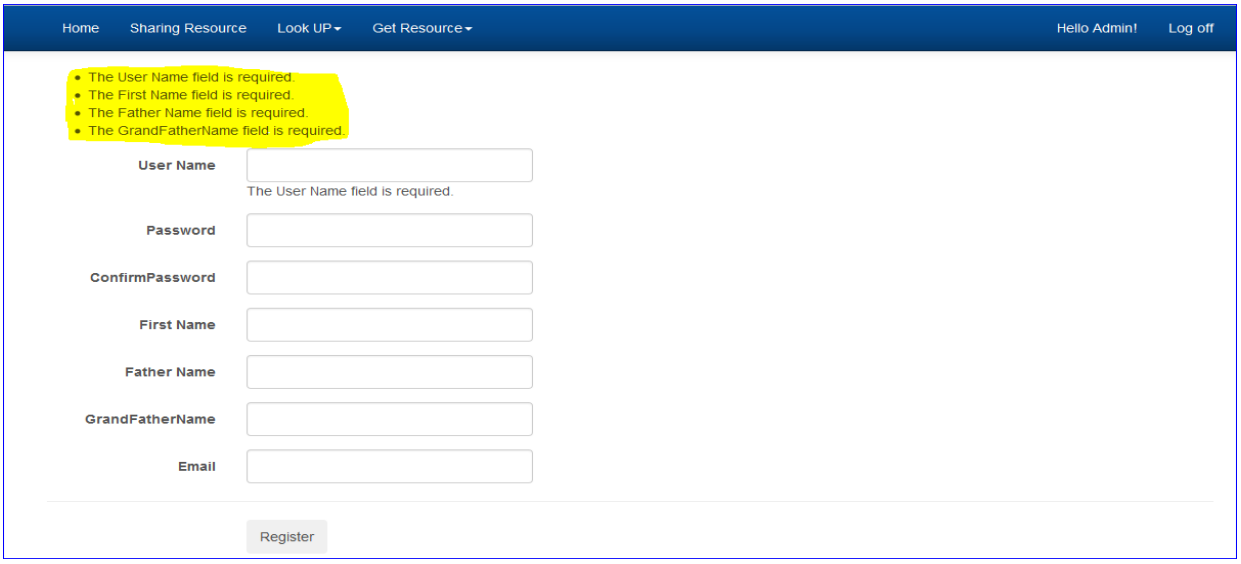



Figure 6.2 user create testing

### 6.2.3. Testing document uploading

Admin and Instructor user can upload document. If the admin and instructor miss input field, the system rejects create document and display on the screen the generation field and form field is required. Bellow the figure shows the user miss the generation field and the from field.

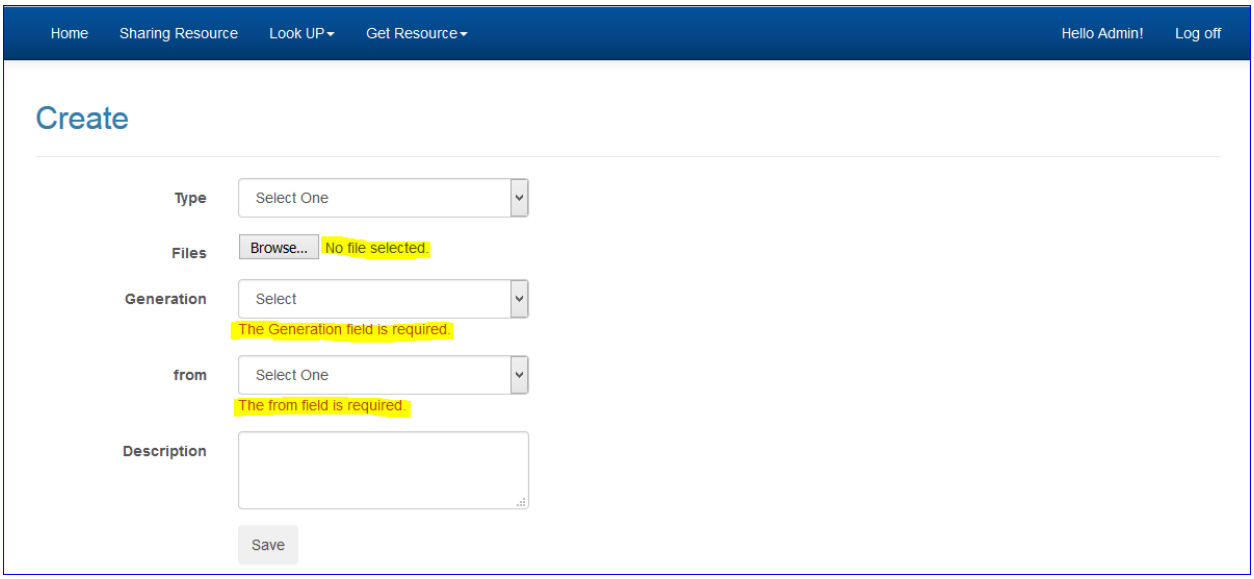



Figure 6.3 Document Uploading Testing

### 6.2.4. Testing change password

When the user wants to Change the password, the user must first input the old password and the new password including confirm password. If the user input is correct ,a successful message shows on the screen, indicates change the password is successfully .But if the user miss the input fields ,an error message should pop up on the screen that indicates the old password field and the new password field is required.

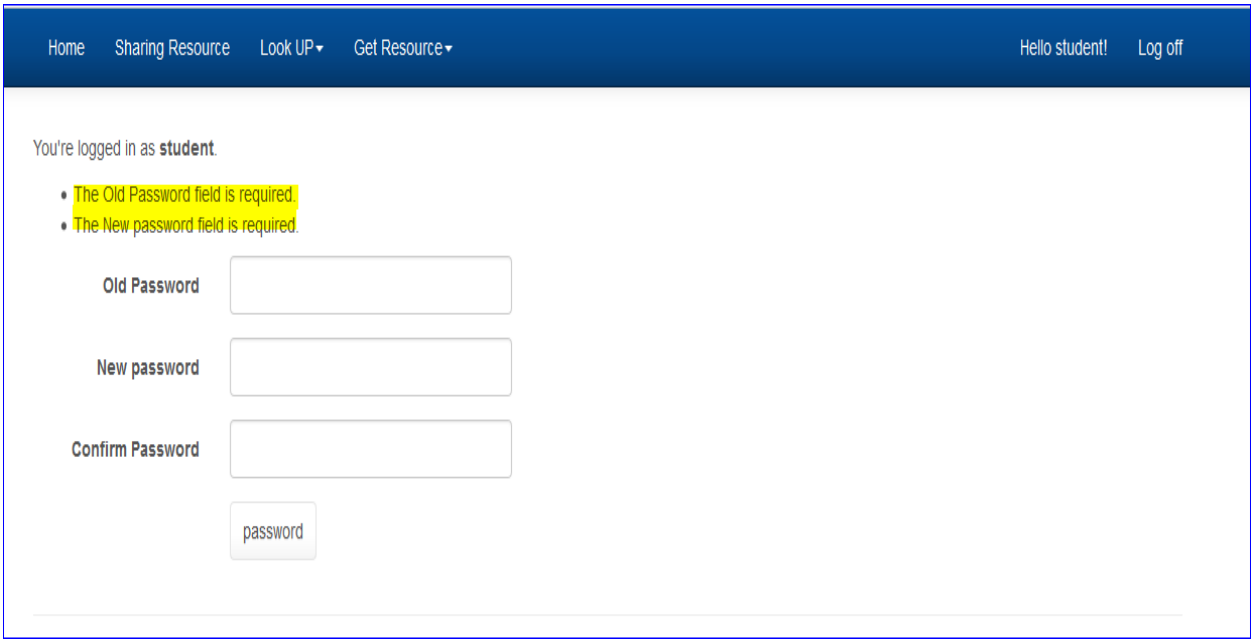



Figure 6.4 Testing change password

## 6.3. Validation of Results

In the previous section we discussed the functional validity testing. In this section, we explain surveys that we conducted with users in order to evaluate and validate the developed prototype system. Ten close ended questions is designed that is further divided in to 5 goal: goal 1 is to assess user interface attractiveness, goal 2 is to evaluate the user friendliness, goal 3 is to measure the performance of the system ,goal 4 is to assess the system reliability and goal 5 is to measure the efficiency of the system. For these questionnaires twenty sample size of population is selected:  5 students, 10 HEI teachers and 5 from ministry of education ICT center workers.

To evaluate the response of the questionnaires, we used the Likert scale one to five i.e. is 1 (poor), 2(fair), 3(good), 4(very good), 5(excellent).The following table shows the evaluation parameter, evaluation questionnaires and the response.

**Table 6.1 Evaluation Response**

| No | Evaluation criteria | | 1 (Poor) | 2 (fair) | 3 (good) | 4 (V.good) | 5 (Excellent) |
|---|---|---|---|---|---|---|---|
| 1. | User Attractiveness | 1. How do you think the prototype system of the user interface attractiveness? | | | 3 | 14 | 3 |
| | | 2. Are you satisfied the new prototype system? | | | | 17 | 3 |
| 2. | User friendliness | 1. How do you think the developed prototype system to access and start using the service? | | | 8 | 11 | 1 |
| | | 2. Is the developed prototype system ease of use? | | | | 18 | 2 |
| 3. | Reliability | 1. Do you think that this system make easier to get necessary resources for your work? | | 6 | 9 | 3 | 2 |
| | | 2. Do you think a cloud computing can improve the task of document sharing with other higher education institutions? | | 2 | 8 | 10 | |
| 4. | Performance | 1. How would you rate the response time when you performed keyboard and mouse actions on the prototype system? | | | 12 | 5 | 3 |
| | | 2. How is the browser response time when you start to request a service on the server? | | 2 | 14 | 4 | |
| 5. | Efficiency | 1. Is using the cloud computing solution is cost effective in academic resource sharing? | | | 3 | 11 | 6 |
| | | 2. Do you think that a cloud computing solution can improve academic resources utilization? | | | 7 | 12 | 1 |

### 6.3.1. Discussion and Results

**Goal 1: To Assess user Interface Attractiveness**

Two questions are asked to evaluate the goal 1. Cumulative results of two questions are shown in Table 6.2 and figure 6.5. Table shows that 15% of the responses are V.good, 3% and 2% of the responses are good and excellent respectively. Figure 6.5 presents the result of table 6.2 graphically.

**Table 6.2.cumulative analysis of Goal 1**

| Q.No | Poor | Fair | Good | V.good | Excellent |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 3 | 14 | 3 |
| 2 | 0 | 0 | 3 | 16 | 1 |
| Total | 0 | 0 | 6 | 30 | 4 |
| Average | 0 | 0 | 3 | 15 | 2 |

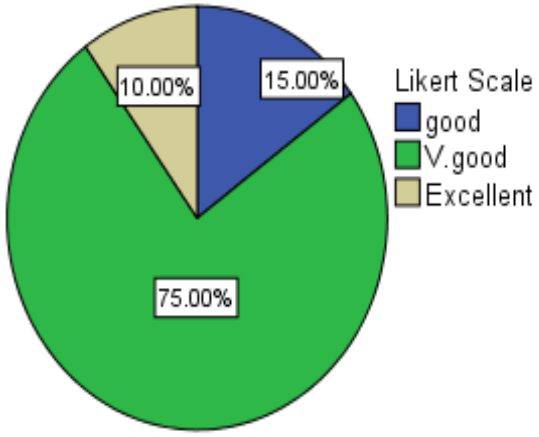



Figure 6.5 cumulative analysis of Goal 1

**Goal 2: To Evaluate user friendliness**

Two questions are asked to evaluate the goal 2. Cumulative results of two questions are shown in Table 6.3 and figure 6.6. Table shows that 13% of the responses are V.good, 5.5% and 1.5% of the responses are good and excellent respectively. Figure 6.6 presents the result of table 6.3 graphically.

**Table 6.3 cumulative analysis of Goal 2**

| Q.No | Poor | Fair | Good | V.good | Excellent |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 8 | 11 | 1 |
| 2 | 0 | 0 | 3 | 15 | 2 |
| Total | 0 | 0 | 11 | 26 | 3 |
| Average | 0 | 0 | 5.5 | 13 | 1.5 |

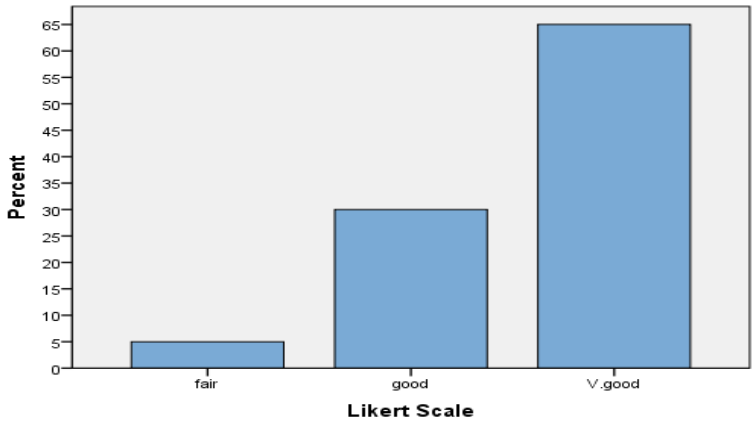



Figure 6.6 cumulative analysis of Goal 2

**Goal 3: To measure the system performance**

Two questions are evaluated in the questionnaire against goal 3 to conclude the result. Table 6.4 shows that 8.5% of responses are good, 6.5% of the responses are V.good, 4% and 1%of the respondents are fair and excellent respectively. Figure 6.7 displays the results of Table 6.4 graphically.

**Table 6.4 cumulative analysis of Goal 3**

| Q.No | Poor | Fair | Good | V.good | Excellent |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 12 | 5 | 3 |
| 2 | 0 | 2 | 14 | 4 | 0 |
| Total | 0 | 2 | 26 | 9 | 3 |
| Average | 0 | 1 | 13 | 5.5 | 1.5 |

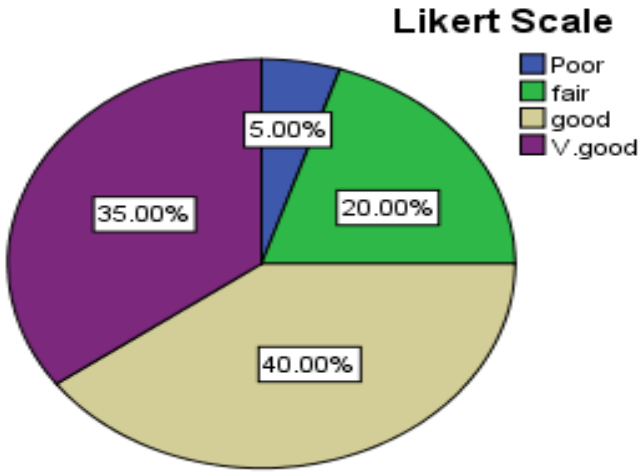


Figure 6.7 cumulative analysis of Goal 3

**Goal 4: To assess the system reliability**

Two questions are evaluated in the questionnaire against goal 4 to conclude the result. Table 6.4 shows that 13% of responses are good, 5.5% of the responses are V.good, 1.5% and 1% of the respondents are excellent and fair respectively. Figure 6.8 displays the results of Table 6.5 graphically.

**Table 6.5 cumulative analysis of Goal 4**

| Q.No | Poor | Fair | Good | V.good | Excellent |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 12 | 5 | 3 |
| 2 | 0 | 2 | 14 | 4 | 0 |
| Total | 0 | 2 | 26 | 9 | 3 |
| Average | 0 | 1 | 13 | 5.5 | 1.5 |

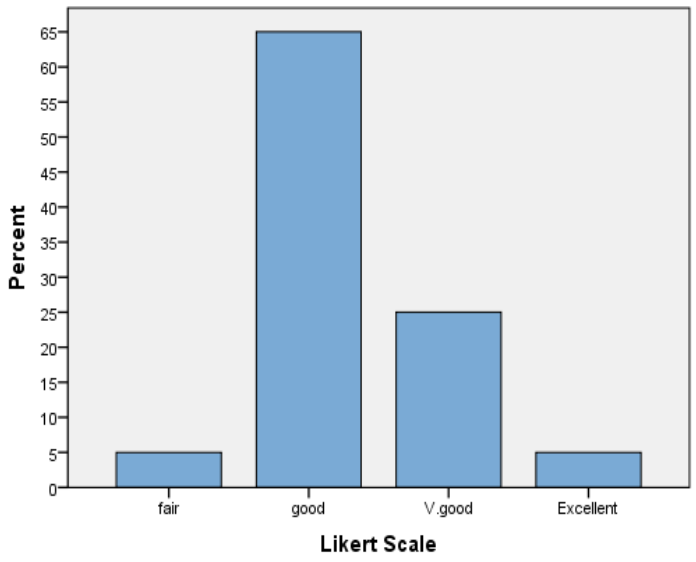



Figure 6.8 cumulative analysis of Goal 4

**Goal 5: To measure the system Efficiency**

Two questions are asked to measure the efficiency of the system. Cumulative results of two questions are shown in Table 6.6 and figure 6.9. Table shows that 11.5% of the responses are V.good, 5% and 3.5% of the responses are good and excellent respectively. Figure 6.9 presents the result of table 6.6 graphically.

**Table 6.6 cumulative analysis of Goal 5**

| Q.No | Poor | Fair | Good | V.good | Excellent |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 3 | 11 | 6 |
| 2 | 0 | 0 | 7 | 12 | 1 |
| Total | 0 | 0 | 10 | 23 | 7 |
| Average | 0 | 0 | 5 | 11.5 | 3.5 |

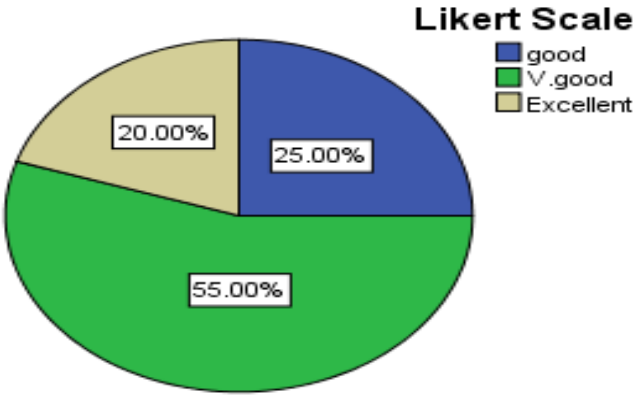



Figure 6.9 cumulative analysis of Goal 5

**6.3.2 Summary of Results Collected**

The Current practice of educational resource sharing in HEI is through manual method using electronic devices like flash disk, CD/DVD drive and paper hardcopy and sometime they used emails and social media sites to share the resources; Even-though they used emails and other social media, still sharing educational resource in HEI needs high cost, more time ,the resource is not available anytime,anwhere, and it's difficult to get the resource on time; In addition, there is no habit or experience of collaborating and sharing educational resources in each HEI ;means HEI students, teachers and staffs did not access the resources as they need and could not collaborate to share educational resources with their friends, peers and among HEI community.

Keep in mind all the above problems, we proposed cloud based platform architecture and prototype system has been implemented which creates common alliance to share educational

resources in HEI. A survey were conducted to validate the proposed architecture and the developed prototype system and the respondents results presented in tabular and bar chart as shown in section 6.3.1.The collected results indicates that the prototype system is cost effective, interactive, reliable and efficient than the manual method and also easy for collaboration, sharing and accessing any educational resources in their professions.

Compared with the manual method, it is increasing availability and collaboration with other HEI. The proposed cloud based platform architecture increases availability and sharing of educational resources among the HEIs and higher education academicians. This also creates an opportunity for the learners to get other HEI educational resources in one place which reduces high cost and time.

Therefore, the proposed architecture and the implemented prototype system seems to have capability of sharing and accessing resources of all types documents such as word document, PDF files, text files, excel files, pictures,. So it adds more flexibility in accessing resources that can be used for the learners. Also the prototype is customizable and managed by the cloud provider which reduces management overhead, the interactive user interface allows to easily registering and login to the system to access all shared resources and to share educational resources, therefore increases collaboration of HEI. Also, using cloud computing we can built and implement reliable and accessible architecture and application to access educational resources anytime, anywhere and which makes to increase the learning experience of in each higher education institutions.

# Chapter Seven: Conclusion and Future Research Direction

## 7.1. Conclusion

Despite its critics and drawbacks, it seems that Cloud Computing should be consider in any sector. Present economic situation will force more and more organizations to at least consider adopting a cloud solution. Universities have begun to adhere to this initiative and there are proofs that indicate significant decreasing of expenses due to the implementation of cloud solutions.

The aim of this work was to identify the particularities of using Cloud based architecture within Higher Education Institutions in Ethiopia. Mainly, we have considered cloud based architecture for educational resource sharing in EHEIs. And also the study presents a cloud computing resource sharing adoption framework and a roadmap HEIs. we also presents, four platform as a service(PaaS) cloud tools and through analysis ,the researcher reached a conclusion Microsoft window azure is a best fit platform for this study. Based on IBM and NIST cloud reference architecture, we designed cloud based architecture for educational resource sharing. For the designed architecture a prototype system has been developed on window azure platform and we assigned the application name http://www.Ethio_HEIResourceSharing.com

The developed prototype web application is tested and evaluated by different users. We have presented the results using frequency table, pie chart and bar graph. The proposed architecture is just the road map for the implementation of a whole virtual cloud based teaching-learning and service delivery ecosystem. After the system is ready to use an independent study comparing the teaching-learning process and service delivery using the proposed architecture with the original teaching-learning process and service delivery environment should be conducted.

## 7.2. Future Work

The research possibilities regarding Cloud Computing for educational purposes are immense since the technology is relatively new. Research in the education fields has much to be examined, but there is not yet a clear definition and standard for such technology. The movement will be rapid after the standardization. Here is a list of some of the future work to be done:

1) The proposed architecture should be implemented in each higher education institutions and tested with iterative feedback reflection from the users so that the proposed architecture will be modified based on the feedback before the architecture full implementation for all universities.

2) Implement the architecture and measure the framework's effectiveness by having different users. One group of users should use the cloud for every service and the other group of users without using the cloud for their work. Example take two classes who study the same course, the first should use the cloud for course materials, assignments and related course work, and the other class without Cloud based applications.

3) Compare the implementation of the architecture on the public Cloud, private Cloud, and hybrid Cloud by highlighting the strengths and weaknesses of each Cloud architecture while considering the performance and security issues. In addition the comparison study may consider the cost, ease of learning, network latency, ease of use, and any other important measurements.

# References


[1] B. A. Nan Cenka and Z. A. Hasibuan, “Enhancing educational services using cloud technology,” *Inf. Commun. Technol. (ICoICT), 2013 Int. Conf.*, pp. 155–160, 2013.

[2] “Enhancing Cloud based E- Learning using Knowledge Sharing System,” vol. 84, no. 9, pp. 26–30, 2013.

[3] C. Study, “The Adoption of Cloud Computing Technology in Higher Education Institutions : Concerns and Challenges.”

[4] H. Qi and A. Gani, “Research on mobile cloud computing: Review, trend and perspectives,” *2012 2nd Int. Conf. Digit. Inf. Commun. Technol. its Appl. DICTAP 2012*, pp. 195–202, 2012.

[5] S. Fentahuen and S. Velagapudi, “Cloud Computing Based HPC : A Framework for Ethiopian Universities,” pp. 4124–4130, 2014.

[6] Z. S. Alkindi, J. Haynes, and S. Arockiasamy, “A Conceptual Architectural Framework of Cloud Computing for Higher Educational Institutions in the Sultanate of Oman,” vol. 6, no. 9, pp. 482–487, 2015.

[7] M. S. Adrees, M. Kamal, and A. Omer, “C LOUD C OMPUTING A RCHITECTURE FOR H IGHER E DUCATION IN T HE T HIRD W ORLD C OUNTRIES ( R EPUBLIC OF T HE S UDAN AS M ODEL ),” vol. 7, no. 3, pp. 13–24, 2015.

[8] S. Saidhbi, “A Cloud Computing Framework for Ethiopian Higher Education Institutions,” *J. Comput. Eng.*, vol. 66, no. 6, pp. 1–9, 2012.

[9] S. Kumar, “Cloud Computing for Universities : A Prototype Suggestion and use of Cloud Computing in Academic Institutions,” vol. 70, no. 14, pp. 1–6, 2013.

[10] G. Eugene, “Cloud Computing Models,” *Massachusetts Intitute Technol.*, no. January, pp. 1–81, 2013.

[11] “Higher Education Research and Network Agency.” [Online]. Available: https://www.ubuntunet.net/ethernet. [Accessed: 12-Dec-2015].

[12] C. Computing, “Cloud Computing for research and science : a holistic overview , policy , and recommendations Final Version,” no. October, pp. 1–59, 2012.

[13] M. Hamdaqa and L. Tahvildari, *Cloud Computing Uncovered: A Research Landscape*, vol. 86. 2012.

[14] F. C. Computing, “Advances in Clouds.”

[15] S. Kumar and R. H. Goudar, “Cloud Computing – Research Issues , Challenges , Architecture , Platforms and Applications : A Survey,” *Int. J. Futur. Comput. Commun.*, vol. 1, no. 4, p. 5, 2012.

[16] N. K. Salih and T. Zang, “Survey and comparison for Open and closed sources in cloud computing.”

[17] N. C. Computing, “Aneka : A Software Platform for.”

[18] “An Advanced Cloud-Based e-Learning Platform for Higher Education for Low Speed Internet Sila Chunwijitra DOCTOR OF Department of Informatics , School of Multidisciplinary Sciences , The

Graduate University for Advanced Studies ( SOKENDAI ),” vol. 2013, no. September, 2013.

[19] S. Jadhav, I. J. Volume, and C. Engineering, “ISSN 2320 – 2629 – October International Journal of Science and Applied Information Technology Available Online at http://warse.org/pdfs/ijiti01112012.pdf E-Education using Cloud Computing,” pp. 1–5, 2012.

[20] M. Kurta, “On the Road Towards Cloud Computing Services,” no. August, 2010.

[21] P. Commissioner, “Modelling Cloud Computing Architecture Without Compromising Privacy : A Privacy by Design Approach,” no. May, 2010.

[22] M. H. Abid, F. Jan, T. Mustafa, and M. S. Faridi, “Cloud Computing : A General User ’ s Perceptions and Security Issues at Universities of Faisalabad , Pakistan,” 2012. .

[23] S. Analyst and C. P. Lead, “Public Cloud The Key to a Successful Digital Transformation.”

[24] V. H. Pardeshi, “Cloud Computing for Higher Education Institutes : Architecture , Strategy and Recommendations for Effective Adaptation,” *Procedia Econ. Financ.*, vol. 11, no. 14, pp. 589–599, 2014.

[25] T. A. Tønnesland, “Evaluation of a Private Cloud for Higher Education,” no. June, 2013.

[26] N. Nagar and U. Suman, “Architectural Comparison and Implementation of Cloud Tools and Technologies,” vol. 3, no. 3, 2014.

[27] S. Al Noor, G. Mustafa, S. A. Chowdhury, Z. Hossain, and F. T. Jaigirdar, “A Proposed Architecture of Cloud Computing for Education System in Bangladesh and the Impact on Current Education System,” *J. Comput. Sci.*, vol. 10, no. 10, pp. 7–13, 2010.

[28] S. B. K. Mehmet Fatih Erkoç, “Cloud Computing For Distributed University Campus: A Prototype Suggestion,” *Conf. Futur. Educ. Firenze*, 2011.

[29] “By:- sewale belachew demeke,” 2012.

[30] G. Zhao, C. Lijuan, and Y. Qiuxu, “Applied Research of Cloud Computing on the Sharing of Educational Information Resource,” no. Icetms, pp. 1346–1349, 2013.

[31] M. Yuvaraj, “Resource Sharing in Libraries on Cloud Landscape : Potentials and Paradoxes,” vol. 2, no. 5, 2013.

[32] M. Alemu and A. Omer, “Cloud Computing Conceptual Security Framework for Banking Industry,” *J. Emerg. Trends Comput. Inf. Sci.*, vol. 5, no. 12, pp. 921–930, 2014.

[33] A. Jenhani, “CLOUD COMPUTING IN GERMAN Bachelorarbeit,” 2011.

[34] A. Singh and M. Shrivastava, “Overview of Attacks on Cloud Computing,” *Int. J. Eng. Innov. Technol.*, vol. 1, no. 4, pp. 321–323, 2012.

[35] O. Article, “Developments in integration of advanced monitoring systems,” pp. 1613–1632, 2014.

[36] Y. Wei, K. Sukumar, C. Vecchiola, D. Karunamoorthy, and R. Buyya, “Chapter 27 Aneka Cloud Application Platform and Its Integration with Windows Azure,” pp. 1–29.

[37] “Collaboration in resource sharing among malaysian academic libraries in a digital environment,” pp. 1–14.

[38] M. Odeh and K. Warwick, “The Impacts of Cloud Computing Adoption at Higher Education Institutions : A SWOT Analysis,” vol. 127, no. 4, 2015.

[39] A. M. Elamir, N. Jailani, and M. A. Bakar, “Framework and Architecture for Programming Education Environment as a Cloud Computing Service,” *Procedia Technol.*, vol. 11, no. Iceei, pp. 1299–1308, 2013.

[40] B. H. Alamri and M. R. J. Qureshi, “Usability of Cloud Computing to Improve Higher Education,” no. August, pp. 59–65, 2015.

[41] C. Zou, “Design and Implementation of Hybrid Cloud Computing Architecture Based on Cloud Bus Design and Implementation of Hybrid Cloud Computing Architecture Based on Cloud Bus,” no. May, 2016.

[42] B. Aljebreen, A. Dahanayake, and L. Syed, “Advances in Higher Educational Resource Sharing and Cloud Services for KSA,” *Int. J. Comput. Sci. Eng. Surv.*, vol. 6, no. 3, pp. 25–40, 2015.

[43] W. Scacchi, “Process Models in Software Engineering,” no. May, pp. 1–24, 2012.

[44] A. Kak, “IBM Cloud Computing Reference Architecture.”

# Appendix

## Appendix A: Interview Questions

1. Is there any mechanism in HEI that helps students, teachers and academic staff collaborate with each other and share educational data?
2. What are the basic issues that prevent to share educational resources effectively in higher education institutions?
3. What are the ICT services and supports that are provided to the university community by your office?
    a. For Teaching learning process, students, lecturers and researchers?
    b. For Administrative Staffs like, Registrar offices, finance offices, human resource offices and related offices in the university?
4. Do you think these services are enough to achieve your mission and vision, supporting quality education, and creating qualified professionals?
5. What are the limitations in providing the above discussed services?
6. Do you think that these universities have work cooperatively with other university especially in educational resources sharing?
    a. If you say yes, justify how resources sharing are takes place.
    b. If you say No, describe the problem.
7. What is your suggestion in formulating a new paradigm for providing educational resources sharing and collaboration in the university? As an ICT director, what do you think is best strategy to provide ICT services for Higher education institutions all over the country to support with the current economic level of Ethiopia?
8. What are the requirements of higher educational institutions toward cloud computing?
9. If a central cloud computing infrastructure is to be built in Ethiopia that could be used by all higher education institutions of the country including your university to provide ICT services, what will be your reaction to this strategy, what kind of services your university need from the cloud?
10. What kind of cloud computing deployment model is the more suitable for higher educational institutions?

**Appendix B: Questionnaire Questions**

**Part one: Personal Information**

Would you please put tick (√) beside the appropriate answer?

**1. Gender**: ☐ Male ☐ Female

**2. Qualification:**

☐ Bachelor ☐ Master ☐ PHD

**3. Age (in years)**

☐ Below 30 years ☐ from 30 – below40 ☐ From40 –below50 ☐ above 50 years

**4. Type of Position**

☐ Administrative ☐ Academy ☐ Academy with administrative position

**5. Position**

☐ Dean ☐ Vice Dean ☐ Head of Department ☐ Director ☐ Assistant Director ☐ Lecture ☐ Other

**6. Years of Experience**

☐ Less than 5 ☐ From 5 – less than 10

☐ From10–less than 15 ☐ Above 15 years

**Part Two: Questions on Educational resources sharing in HEI**

1. Do you think that Ethiopian higher education institution share academic resources effectively and properly? If you say "yes", justify how they can share and if you say "No" mention the reason that prevent academic resources sharing among higher education.

☐ Yes ☐ No ☐ Unsure

_____

_____

_____

_____

2. Do you think that higher education institutions work corporately with each other especially in educational resources sharing?

☐ Highly corporate ☐ Moderate corporate ☐ Low corporate

3. Do you believe that the current resources sharing mechanism well designed and integrated with different client devices?

☐ Yes ☐ No ☐ Unsure

4. Is the current resources sharing approach is effective and efficient in terms of the following variables?

- ✓ Cost Accessibility
- ✓ Availability Reliability
- ✓ Speed Confidentiality
- ✓ Security

☐ Yes ☐ No ☐ Unsure

**Part Three: Questions on ICT services and cloud computing technologies**

5. Is your institution ICT center can able to support new emerged technology and to provide different ICT service?
6. Does your institution focus on and plan to use the new emerged technology, which aim to increase the efficiency and quality of services provided for the learners and the university community?
7. Does your institution use or plan to use cloud computing? If you say "yes", mention the advantage and disadvantage ,If you say "No", give a personal opinion about cloud computing

☐ Yes ☐ No ☐ unsure

_____

_____

_____

8. Do you think that using cloud computing technology at the institutions helps to improve the current service and to activate new service?
9. How do you think that design a central cloud based system to store and share educational resources?

☐ Strongly Agree ☐ Fairly Agree

☐ Agree ☐ Partially Agree ☐ Nearly Agree`

10. Do you believe that cloud based architecture for educational resources sharing are better rather than traditional on the accessibility and availability of the resources?

☐ High accessible, available ☐ Medium accessible, available

☐ Low accessible, available ☐ No effect

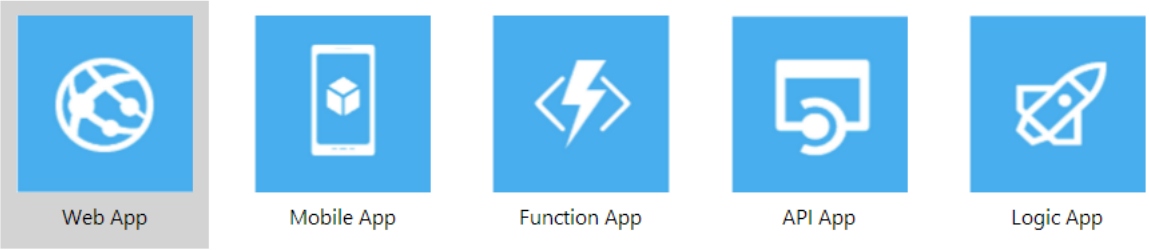
## Appendix C: Working with Microsoft Window Azure Platform

In this section we discussed how to work with Microsoft window azure to develop and host application .So to create the proposed application on window azure platform services: we have used App service; that is the platform services is provided to the user by app service. The APP services enable developers to focus on their code and reach a stable, highly scalable production state quickly. With APP services, we can develop web app, mobile app, API APP, logic API etc. Among this, we have selected the web app services.

### Creating Web APP Service

To create the web app services on the azure app service platform, we have followed the following three steps.

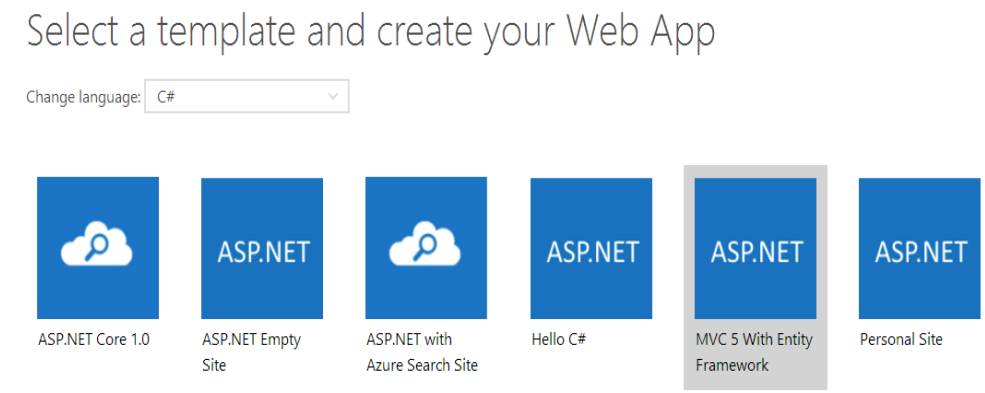
1. Selecting app service type




As we shown in above figure we have selected web app service. Azure Web Apps enable developers to easily deploy and scale enterprise grade web applications written in a variety of languages and integrated with a multitude of services without ever worrying about infrastructure management.

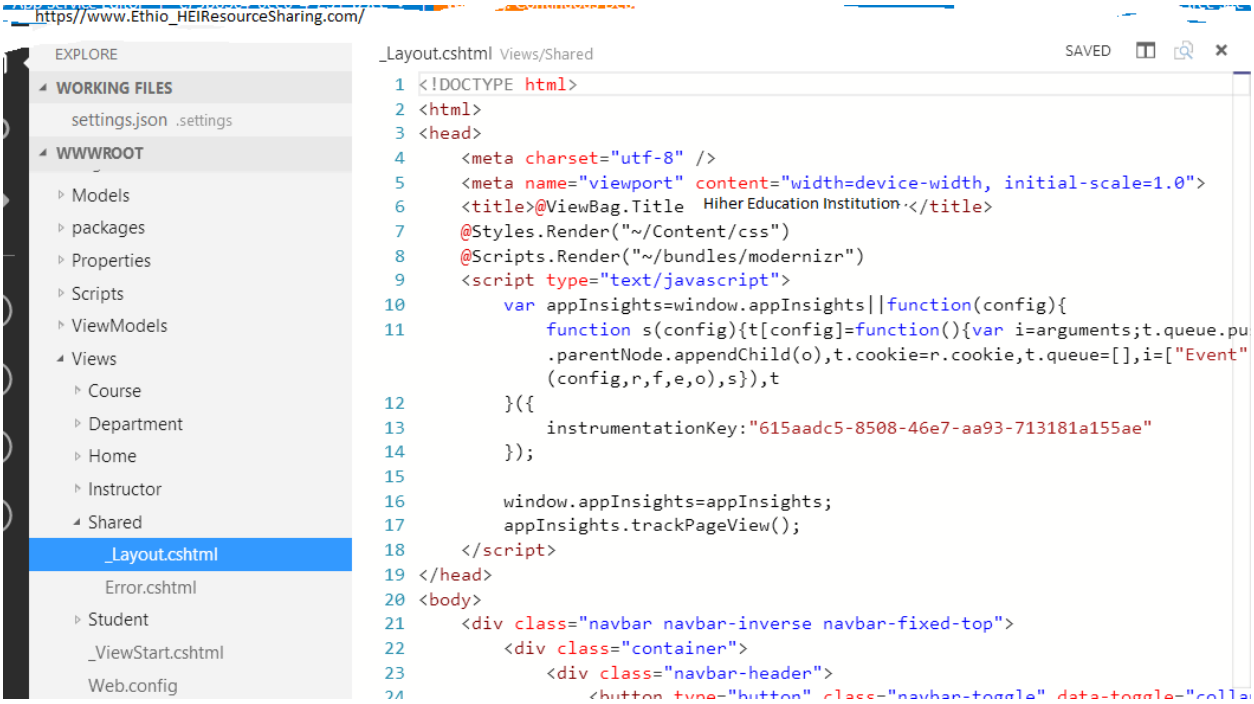
2. Selecting a language

   In window azure platform, there is Visual Studio integration tools that allows for the developer for creating, deploying, and debugging applications in online and at developer local machine. The following diagram shows the language selected and its template.




3. Creating the web app services

In this step we have assigned the application name like this (https//www.Ethio_HEIResourcSharing.com/), as shown the following diagram and then we implemented the modules.



## Appendix D: Sample Code

```
Using System;
Using System.Collections.Generic;
Using System. Data;
Using System.Data.Entity;
Using System.Linq;
Using System.Net;
Using System.Web;
Using System.Web.Mvc;
Using Web. Models;
Using System.IO;

Namespace Web. Controllers
{
    Public class Documents Controller: Controller
    {
        Private PrimeDBContext db = new PrimeDBContext ();

        // GET: Documents
        Public ActionResult Index ()
        {
            Return View (db.Documents.ToList ());
        }

        Public ActionResult IndexFirstGeneration ()
        {
       Return View (db.Documents.Where(x => generation == "First Generation").ToList ());
        }
        Public ActionResult IndexSecondGeneration ()
        {
     Return View (db.Documents.Where(x => generation == "Second Generation").ToList ());
        }
        Public ActionResult IndexThirdGeneration ()
        {
      Return View (db.Documents.Where(x => generation == "Third Generation").ToList ());
        }
        // GET: Documents/Details/5
        Public ActionResult Details (int? id)
        {
            If (id == null)
            {
                Return new HttpStatusCodeResult (HttpStatusCode.BadRequest);
            }
            Document = db.Documents.Find (id);
            If (document == null)
            {
                Return HttpNotFound ();
            }
            Return View (document);
        }

        // GET: Documents/Create
        Public ActionResult Create ()
        {
            ViewBag.Look = new Select List (db. Lookups, "Name", "Name");
            ViewBag.unvr = new SelectList (db.fromUniversities, "Name", "Name");
```