UNIVERSITY OF NAIROBI

A FRAMEWORK FOR CLOUD COMPUTING ADOPTION FOR AGRICULTURAL CONSULTATIVE GROUPS IN KENYA

BY

INDIMULI JAMES STEPHEN MUKABI

A RESEARCH PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN INFORMATION SYSTEMS OF THE UNIVERSITY OF NAIROBI

AUGUST 2013

DECLARATION

This research project report is my original work and has not been submitted for a degree in any other University.

SIGNED: _____ **DATE**: _____

Indimuli James Stephen Mukabi

P56/7351/2006

This research project report has been submitted for examination with my approval as the University Supervisor.

SIGNED: _____ **DATE**: _____

Dr. Elisha T. Opiyo Omulo

ACKNOWLEDGEMENT

I would like to thank my supervisor, the panel, family members, lecturers, colleagues at work and fellow students for the support they have given me. I am very thankful to my supervisor, Dr. Elisha T. Opiyo Omulo for his constructive criticism support and guidance and that enabled me to complete my research project. I also thank my wife Miriam and my mother Sellah for the encouragement and support. Finally, I would like to thank all my family members, friends, classmates, colleagues at ILRI / ICRAF, lecturers, and questionnaire respondents for their contribution towards making this study a great success.

DEDICATION

This project is dedicated to my family for the support and guidance they gave me and the sacrifice they had to make to help me reach this far. My wife and my mother have encouraged me at all times and helped me achieve my goals. A special dedication goes to my late father, Mr. Shadrack Indimuli who passed away when I was still doing my course work.

ABSTRACT

Most organizations are currently focusing on reducing their IT costs, looking for ways to make IT teams leaner and instead concentrating on remaining competitive in the market by putting more of their available resources into their core business as opposed to ICT operations. Therefore, for organizations to compete effectively, they will need IT infrastructure that can scale quickly to meet dynamic business demands and maximize utilization of their IT investments. Traditional IT systems have become more complex and costly to maintain and are no longer able to meet business demands since they lack flexibility and scalability. Cloud computing is the answer to the problems that are currently being experienced by organizations that still have the traditional on-premise IT systems. Cloud computing saves costs by eliminating the need for high infrastructure expenses and also provides an easy to use, cost efficient, flexible, dynamic and secure environment for organizations to conduct their business.

A case study was carried out to examine why Agricultural Consultative Groups (ACGs) have not adopted the Cloud computing technology. The study attempted to find out whether ACGs understand the concept of Cloud computing, its architecture, what it can offer and associated risks challenges ACGs might face when migrating their applications to the Cloud. The study also evaluated the models, architectures, technologies and best practices for ACGs to adopt Cloud computing and explored available decision/migration frameworks. The thesis then analyzed specific strategies which ACGs can adopt to ensure that migration and integration from traditional on-premise systems to the Cloud is seamless.

The determinant factors within each category i.e. individual, organizational, technological and environmental were then analyzed and classified as high priority, medium priority and low priority in a Cloud computing framework. From the eleven Cloud drivers that were analyzed, we can safely say that the most attractive factor when ACGs are making the decision to adopt Cloud technology is Business Continuity and Disaster recovery capabilities. From the fourteen concerns and challenges that were analyzed, the main challenges that ACGs are likely to face when adopting Cloud technology are confidentiality of corporate data and data security.

TABLE OF CONTENTS

Contents

LIST OF FIGURES

Page No.

LIST OF TABLES

Page No.

LIST OF ACRONYMS AND ABBREVIATIONS

ACG :	Agricultural Consultative Group
AWS :	Amazon Web Service
BCP:	Business Continuity Planning
CapEx :	Capital Expenses
CGIAR:	Consultative Group on International Agricultural Research
CIO :	Chief Information Officer
DOI:	Diffusion of Innovation
DR:	Disaster Recovery
DTPB:	Decomposed Theory of Planned Behavior
IaaS :	Infrastructure as a service
ICRAF:	International Center for Research in Agroforestry
ICT :	Information and Communication Technology
IDT:	Innovation Diffusion Theory
ILRI :	International Livestock Research Institute
IP:	Internet protocol
IT :	Information Technology
NARS :	National Agricultural Research Systems
NGO :	Non Governmental Organization
OS :	Operating System
PaaS :	Platform as a service
PC :	Personal Computer
POC:	Proof of concept
QoS :	Quality of service
SaaS :	Software as a service
SCT:	Social Cognitive Theory
SLA:	Service Level Agreements
SLT:	Social Learning Theory
SOA:	Service Oriented Architecture
TAM:	Technology Acceptance Model
TPB:	Theory of Planned Behavior
TRA:	Theory of Reasoned Action
VPN :	Virtual Private Network

1.0 INTRODUCTION

1.1 Background

For the purpose of this research study, Cloud computing has been defined as a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or Cloud provider interaction.

Once every five years or so a profound change flows across the IT ecosystem – World bank report (2010). In the early 1990s, the Internet transformed the way businesses communicate. By the mid-90s, e-commerce virtualized purchasing for customers and business partners. A decade later, offshoring took hold – and took a lot of in-house business functions to China, India, and other low-cost centers around the world.

Today, Cloud computing is sweeping over the information technology landscape, bringing broad changes in the way IT services are designed, delivered, consumed, and managed.
Demand for cloud computing – and its predecessors, virtualization and off-premise services – has been fueled by the lingering effects of the global recession, which forced many organizations to trim their cost structure (capital and operating) while still meeting customer demands. While this - do more with less mandate is still in effect at most companies, many CEOs are now asking their organizations to prepare the business for growth.
Cloud computing is a strategic initiative for organizations that aims to strike the right balance between lowering costs and enabling growth.

Cloud computing provides a proven means to efficiently deliver lower IT capital costs and increased operating efficiencies. Yet concerns about information security, service availability, performance, and the complexity of integration have dissuaded many CIOs.

Kevin Yin (2010) explains that data centers are platforms of traditional enterprise IT applications. They have stack architecture, including IT resources and isolated IT applications. However, as the number of enterprise IT applications grow, traditional data center architecture will no longer be capable of meeting market demands. In past years, the total number of resources—including servers and storage devices—increased by 40%-70%

each year, while the average utilization of resources was only 10%-25%. An increase in the number of physical resources leads to increased electricity and cooling costs as a proportion of overall data center costs. This proportion has reached up to 25%-30% in recent years. A large number of physical resources also makes data center deployment more complicated, and increases the risk of data center faults due to human error. Up to 54% of data center faults involve human error, and this can blow out maintenance costs too. ICT applications are continually emerging, Web2.0 applications are being quickly implemented and deployed, and service oriented architecture (SOA) is developing quickly. Therefore, transition from enterprise data centers to Cloud computing infrastructure will become imperative. It is no longer a matter of if but when the transition will occur.

This research is aimed at helping agricultural research institutions in Kenya make an informed decision when adopting Cloud technology. Agricultural research institutions are grouped into various categories that include: National Agricultural Research Systems (NARS), International Organizations, Regional and Eco-regional Organizations, Agricultural Research Institutes , Non-Governmental Organizations (NGOs) and Consultative Group on International Agricultural Research (CGIAR) Centers. This study will focus on the category of CGIAR centers only and the scope will be limited to Kenya. In Kenya, we have International Livestock Research Institute and World Agroforestry (ICRAF) as the only CGIAR centers. For purposes of this study, the two centers will be classified under agricultural consultative groups (ACGs)

1.2 Statement of Research Problem

Cloud computing has gained prominence over the last few years. This is because of the various advantages of moving applications to the Cloud and the fact that by migrating to the Cloud, organizations are able to respond fast to the needs of their business and therefore drive greater operational efficiencies.

Because donor-funded Agricultural Consultative Groups (ACGs) play a crucial role in the world agricultural economy, it is important that their operations are resilient and the effects of disruptions in service are minimized in order to maintain donor confidence, institute reputation in the research community, staff morale and regulatory and contractual requirements.

ACGs have been hesitant to migrate applications to the Cloud and as such they are missing out on the opportunities that migrating applications comes with. The current on-premise computing has limitations /disadvantages which include high data center operating costs, underutilization of server resources and lack of flexibility. As demand for services increases, so is the number of physical servers and this pushes up the cost of electricity and general IT administration and other related costs go up.

By moving applications to the Cloud, ACGs will benefit from the following:

- Virtually unlimited processing and storage capacity
- Abstracted, pooled resources
- Elasticity (the ability to scale up or down easily)
- On-demand, self-service provisioning
- High level of automation
- Consumption-based billing

The following research questions guided this case study:

- What is the concept of Cloud computing?
- What is the importance and impact of migrating applications to the Cloud?
- What are the factors that encourage or drive the adoption of Cloud computing technology
- What are the factors that limit the adoption and use of Cloud computing by ACGs in Kenya?
- How can Cloud computing technology be applied to ACGs in Kenya?
- What are the key influencing factors that should be considered when migrating ACGs from the current set up to a Cloud computing environment?

The study has provided a framework for understanding how Cloud computing can be applied at an organizational level. The study focused on how Cloud computing technology can be applied within agricultural research institutes.

1.3 Objectives of the Research

1.3.1 The Goal

The main objective of this research was to design a framework that can be used by Agricultural Consultative Groups in Kenya during migration of their existing computer applications from the traditional on-premise computing to Cloud computing environment.

1.3.2 Specific objectives

- Identify existing on-premise computing and Cloud computing technologies and building a case for ACGs to migrate applications to the Cloud
- Identify Cloud technology drivers
- Identify the determinant factors influencing the adoption of Cloud computing by ACGs
- Identify the degree of influence of each determinant factor in the adoption of Cloud computing technology by ACGs
- Identify the main concerns and challenges that ACGs are likely to face when considering migrating applications to the Cloud
- Formulate the Cloud computing framework for adoption of Cloud technology
- Evaluate the proposed framework

1.4 The Significance of the Study

My motivation of the research follows the recent developments in the computing industry. Organizations are now moving from capital costs to operational costs. This is because no organization wants to constantly keep replacing or upgrading equipment and also sending their IT personnel for training because of technology advancements. This is not only time consuming but also costly to the organization because organizations are no longer able to focus primarily on their core objectives.

The study will be of importance to the following groups:

Agricultural Research Industry

Donors will be excited to know that ACGs are now moving towards having leaner IT teams and investing in services that will only be paid for on demand. This means that ACGs will concentrate on their core business of research and there will be no capital costs of investing in technology. It will be easier to account for donor funds by accurately accounting for operational costs per project.

The Academic Community

The study will contribute to the existing body of knowledge in Cloud computing. The completed study can also be referenced by other scholars who want to carry out further study in the subject area.

1.5 Structure of the Thesis

This thesis assumes that Cloud computing technology is now with us and is only a matter of when and not if enterprises will migrate their applications to the cloud. They will have to go through the decision and migration frameworks to decide what to move to the Cloud, how to do it and when. This thesis is divided into six chapters. The first chapter is the introduction and Chapter 2 looks at trends in computing, the on-premise computing practice and the emerging technology of computing for Enterprises which is Cloud computing. Comparing on-premise computing with Cloud computing forms the foundation for Cloud migration decision process. A conceptual model for this study is also formulated in this chapter. Chapter 3 outlines the research methodology and data collection method. Chapter four focusses on results, data analysis and discussion. Chapter 5 covers conclusion and future recommendations and finally chapter six is the appendix.

1.6 Chapter Summary

This chapter started by giving an introduction of the research problem and the statement of research. The objectives of the research were outlined and the benefits of the research to the different groups stated. The groups to benefit from the research are the ACGs and academic community. Finally there is a brief of the structure of the Thesis. In the next chapter, we shall look at the On-premise traditional computing and compare it with the various Cloud computing models in the market. We shall also look at the pros and cons of each of the models.

2.0 LITERATURE REVIEW

2.1 Current ICT Resources

Before we delve into the Cloud computing technology and available opportunities for organizations, it is important for us to take a critical look at the current computing trends in the industry.

Case for Keeping On-Premise IT

Enterprises have been moving their business processes, IT development and support outside their perimeter Ashok Dhiman (2010). Last decade saw an exponential increase in outsourcing of non-core IT services and business processes. The trend still continues with enterprises pushing boundaries of what to outsource or host external to the organization. While CIOs are making these decisions, they are presented with opportunities in Cloud Computing area. They are confronted with questions like; how can they realize cost and performance benefits out of it. That being said, traditional in-house systems even with their big price tag and high ongoing expenditure seem safe because of the control they provide. These merits do come in to the decision process when IT managers think about migrating to the Cloud. Ashok outlines the following

Technical perspective

1. Data storage and location: Having infrastructure inside your premises gives you control over servers and the data they hold. You know exactly where your data is.
2. Security: Having your own infrastructure within your premise gives you the sense and control of security. You can be flexible with securing your applications and data depending on the criticality.
3. Architecture: On-premise systems give applications high architectural flexibility. Having control over infrastructure, application platforms and development resources, the applications can be customized to better fit the user's needs (albeit at additional costs)
4. Hardware dependencies: Dependencies between different architecture layers can be controlled better in on-premise systems by making needed adjustments and fixes.

Business perspective

1. Ownership of data: Knowing the location and condition of your data gives businesses in enterprise the sense of confidence and control (which is lost when one moves to Cloud). In On-premise systems, enterprise owns the data and can change, use, purge it when they like – they own it.
2. Regulatory issues: Sometimes enterprises might want to move data outside their perimeter because of the cost and performance benefits but regulatory requirements might not allow them to do so.
3. Privacy issues: Having your data hosted out on other vendors' platforms might make it open to government agencies who might be allowed to access based on legislative acts. Having data On-premise gives the control in the hands of enterprise allowing them to take actions best in the interest of company and its customers.
4. Cost/Benefit: There have been various models in support of cost benefit of outsourcing, hosting and Cloud computing but depending on the utilization and scenarios, there might be some cases where On-premise IT can be implemented in a way to justify its cost given other benefits it gives of data control and security.
5. Change management: Sometimes making a decision to move perfectly running systems and applications outside the enterprise does not make sense as the move might bring major changes in business processes, user behavior and in some cases cause system integration nightmares. Change management is the key when planning for Cloud migration.

2.2 State of Cloud Computing

Definition

Cloud computing has been defined by National Institute of Standards and Technology (NIST) as a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or cloud provider interaction

It is a technology that uses the internet and central remote servers to maintain data and applications. Cloud computing allows consumers and businesses to use applications without installation and access their personal files at any computer with internet access. This technology allows for much more efficient computing by centralizing storage, memory, processing and bandwidth.

Cloud computing is a general term for anything that involves delivering hosted services over the Internet. These services are broadly divided into three categories: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS). The name cloud computing was inspired by the cloud symbol that's often used to represent the Internet in flowcharts and diagrams. Figure 1 below captures features of a Cloud

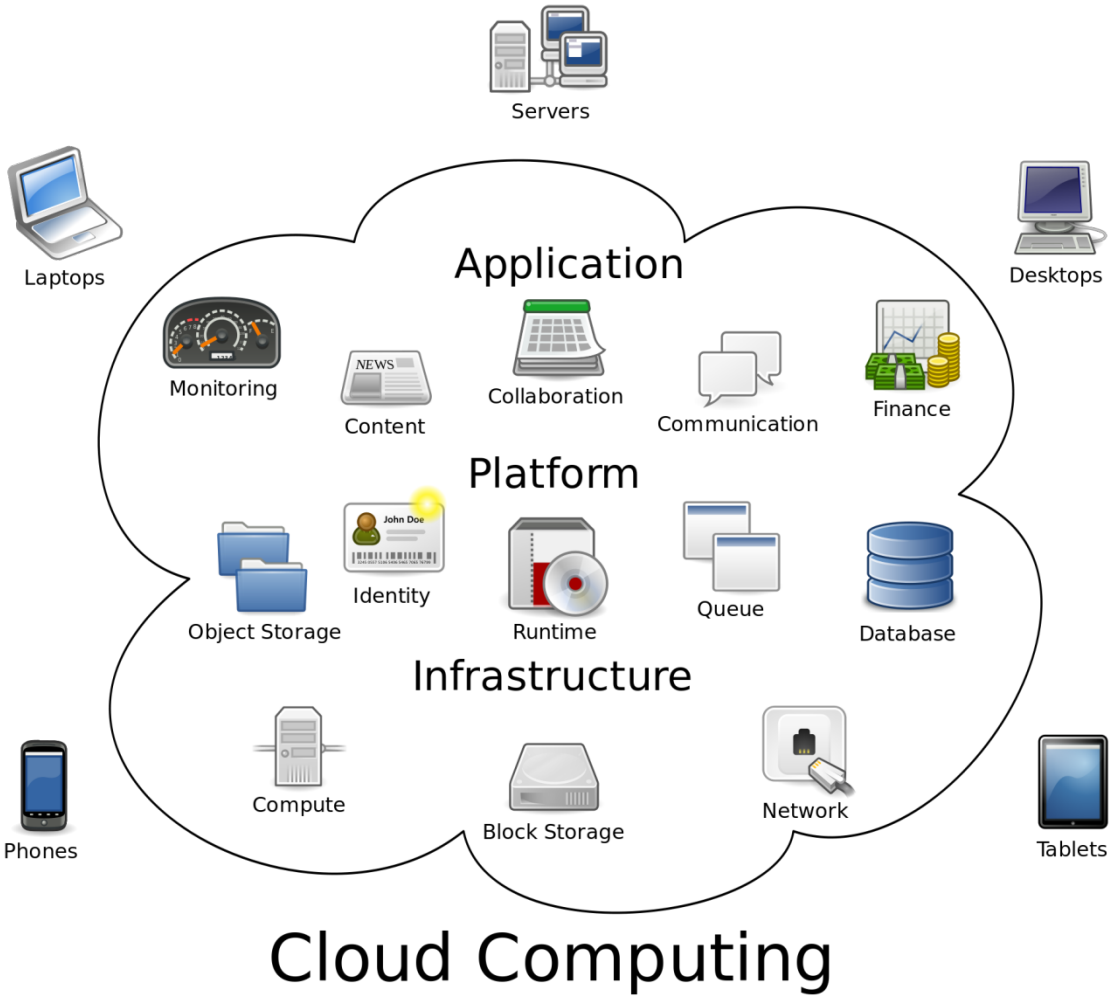

Figure 1 – Cloud computing features – source Wikipedia

A Cloud service has three distinct characteristics that differentiate it from traditional hosting. It is sold on demand, typically by the minute or the hour; it is elastic - a user can have as much or as little of a service as they want at any given time; and the service is fully managed by the provider (the consumer needs nothing but a personal computer and Internet access). Significant innovations in virtualization and distributed computing, as well as improved access to high-speed Internet and a weak economy, have accelerated interest in cloud computing.

Cloud computing delivers IT as a service. It might be your own private cloud accessible only within your organization, the public cloud of an external provider or a hybrid cloud that spans both.

Features of a Cloud include:

- Virtually unlimited processing and storage capacity
- Abstracted, pooled resources
- Elasticity (the ability to scale up or down easily)
- On-demand, self-service provisioning
- High level of automation
- Consumption-based billing

2.2.1 History of Cloud computing

The term "cloud" is used as a metaphor for the Internet, based on the cloud drawing used in the past to represent the telephone network, and later to depict the Internet in computer network diagrams as an abstraction of the underlying infrastructure it represents.

The ubiquitous availability of high capacity networks, low cost computers and storage devices as well as the widespread adoption of virtualization, service-oriented architecture, autonomic, and utility computing have led to a tremendous growth in cloud computing Details are abstracted from end-users, who no longer have need for expertise in, or control over, the technology infrastructure "in the cloud" that supports them.

The underlying concept of Cloud computing dates back to the 1960s, when John McCarthy opined that "computation may someday be organized as a public utility." Almost all the modern-day characteristics of cloud computing (elastic provision, provided as a utility, online, illusion of infinite supply), the comparison to the electricity industry and the use of public, private, government, and community forms, were thoroughly explored in Douglas Parkhill's 1966 book, *The Challenge of the Computer Utility*. Other scholars have shown that cloud computing's roots go all the way back to the 1950s when scientist Herb Grosch (the author of Grosch's law) postulated that the entire world would operate on dumb terminals powered by about 15 large data centers.

The actual term "cloud" borrows from telephony in that telecommunications companies, who until the 1990s offered primarily dedicated point-to-point data circuits, began offering Virtual Private Network (VPN) services with comparable quality of service but at a much lower cost. By switching traffic to balance utilization as they saw fit, they were able to utilize their overall network bandwidth more effectively. The cloud symbol was used to denote the demarcation point between that which was the responsibility of the provider and that which was the responsibility of the user. Cloud computing extends this boundary to cover servers as well as the network infrastructure.

After the dot-com bubble, Amazon played a key role in the development of cloud computing by modernizing their data centers which, like most computer networks, were using as little as 10% of their capacity at any one time, just to leave room for occasional spikes. Having found that the new cloud architecture resulted in significant internal efficiency improvements

whereby small, fast-moving "two-pizza teams" could add new features faster and more easily, Amazon initiated a new product development effort to provide cloud computing to external customers, and launched Amazon Web Service (AWS) on a utility computing basis in 2006

In early 2008, Eucalyptus became the first open-source, AWS API-compatible platform for deploying private clouds. In early 2008, Open Nebula, enhanced in the RESERVOIR European Commission-funded project, became the first open-source software for deploying private and hybrid clouds, and for the federation of clouds. In the same year, efforts were focused on providing QoS guarantees (as required by real-time interactive applications) to cloud-based infrastructures, in the framework of the IRMOS European Commission-funded project, resulting to a real-time cloud environment. By mid-2008, Gartner saw an opportunity for Cloud computing "to shape the relationship among consumers of IT services, those who use IT services and those who sell them" and observed that organisations are switching from company-owned hardware and software assets to per-use service-based models" so that the "projected shift to cloud computing... will result in dramatic growth in IT products in some areas and significant reductions in other areas."

2.2.2 Cloud Service Models

The service model to which a cloud conforms dictates an organization's scope and control over the computational environment, and characterizes a level of abstraction for its use (NIST 2011).

Cloud computing providers offer their services according to three fundamental models: Infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) where IaaS is the most basic and each higher model abstracts from the details of the lower models.

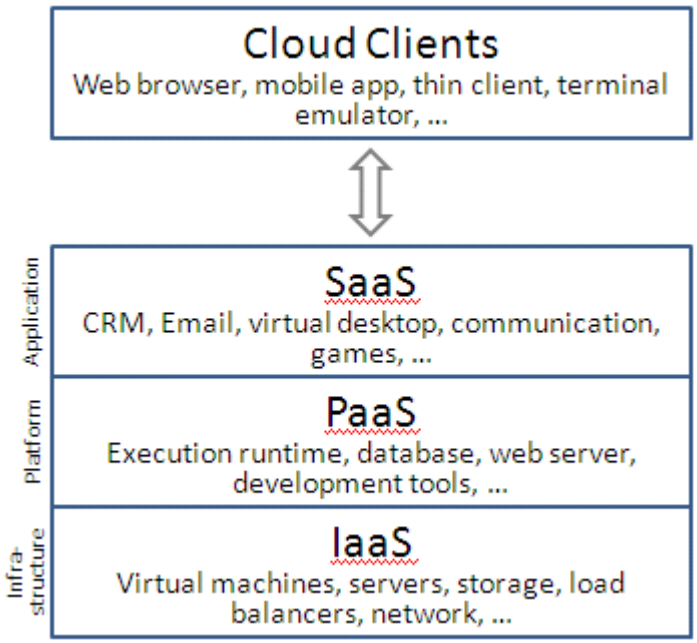

Figure 2 – Cloud service models – source Wikipedia

a) Infrastructure as a Service (IaaS)

In this most basic cloud service model, cloud providers offer computers – as physical or more often as virtual machines, raw (block) storage, firewalls, load balancers, and networks. IaaS providers supply these resources on demand from their large pools installed in data centers. Local area networks including IP addresses are part of the offer. For the wide area connectivity, the Internet can be used or - in carrier clouds - dedicated virtual private networks can be configured.

To deploy their applications, Cloud users then install operating system images on the machines as well as their application software. In this model, it is the cloud user who is

responsible for patching and maintaining the operating systems and application software. It is a well-known fact that except for a few peak times per year, most servers are running with a 7 - 10% load. IaaS enables enterprises to leverage the cloud during peak need times. Doing this is often referred to as Cloud bursting. To accomplish this internally, organizations must use complex resource allocation software.

Cloud providers typically bill IaaS services on a utility computing basis, that is, cost will reflect the amount of resources allocated and consumed.

Advantages/Disadvantages**:** IaaS allows organizations to avoid the large capital expenses associated with infrastructure and data centres. It also has a low barrier to entry and enables automated scaling. One negative aspect of IaaS is that it brings with it new security risks that require different measures. Enterprises must therefore carefully assess where such information resides and mitigate any privacy risks. In addition, how well IaaS works is vendor dependent.

b) Platform as a Service (PaaS)

In the PaaS model, cloud providers deliver a computing platform and/or solution stack typically including operating system, programming language execution environment, database, and web server. Application developers can develop and run their software solutions on a cloud platform without the cost and complexity of buying and managing the underlying hardware and software layers. With some PaaS offers, the underlying compute and storage resources scale automatically to match application demand such that the cloud user does not have to allocate resources manually.

Advantages/Disadvantages**:** PaaS enables enterprises to pool resources, scale when needed, and makes version control simple. However, once again, the largest downside is that centralized data increases security risks.

c) Software as a Service (SaaS)

In this model, cloud providers install and operate application software in the cloud and cloud users access the software from cloud clients. The cloud users do not manage the cloud infrastructure and platform on which the application is running. This eliminates the need to install and run the application on the cloud user's own computers simplifying maintenance

and support. What makes a cloud application different from other applications is its elasticity. This can be achieved by cloning tasks onto multiple virtual machines at run-time to meet the changing work demand. Load balancers distribute the work over the set of virtual machines. This process is transparent to the cloud user who sees only a single access point. To accommodate a large number of cloud users, cloud applications can be multitenant, that is, any machine serves more than one cloud user organization. It is common to refer to special types of cloud based application software with a similar naming convention: desktop as a service, business process as a service, Test Environment as a Service, communication as a service.

The pricing model for SaaS applications is typically a monthly or yearly flat fee per user.

Advantages/ Disadvantages**:** The potential for cost savings using SaaS is obvious. Rather than purchase expensive licenses for each computer, many of which remain idle at any given time, organizations can pay for the use of software by the drink. SaaS also eliminates the capital expense of purchasing software. In addition, since applications are centralized, version control and updates are relatively headache free and deploying software becomes instantaneous. On the other hand, applications that are centralized present enhanced security risks.

Figure 3 below gives describes the differences in scope and control among Cloud service models

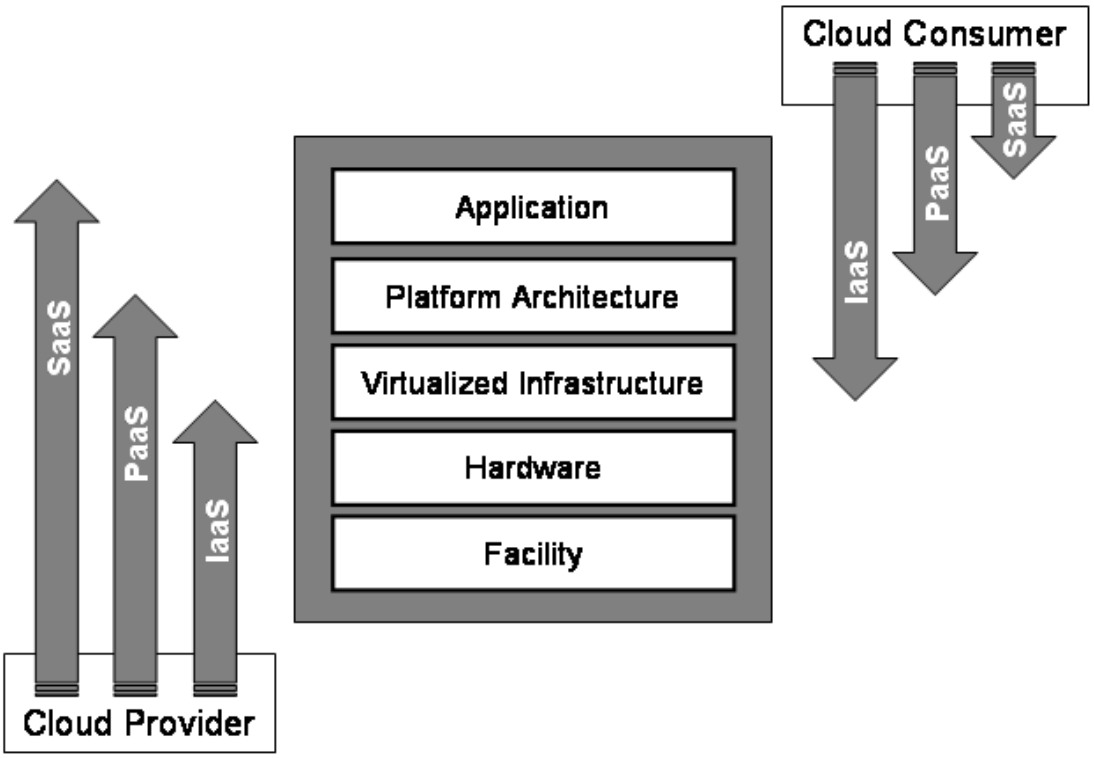

Figure 3: Differences in Scope and Control among Cloud Service Models

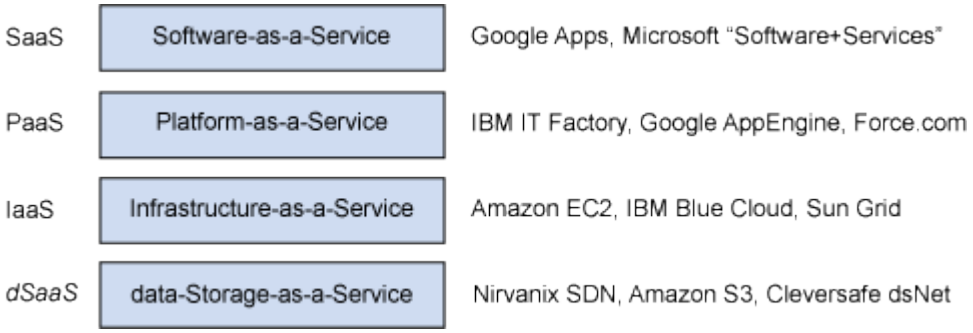

Figure 4 - Cloud computing layers with offerings

This is by no means an exhaustive list of offerings, as it changes quite frequently. However, it does provide an overview of some of the offerings and how they are differentiated.

Figure 5 below captures a summary of the services available to a consumer under the different layers i.e. SaaS, PaaS and IaaS

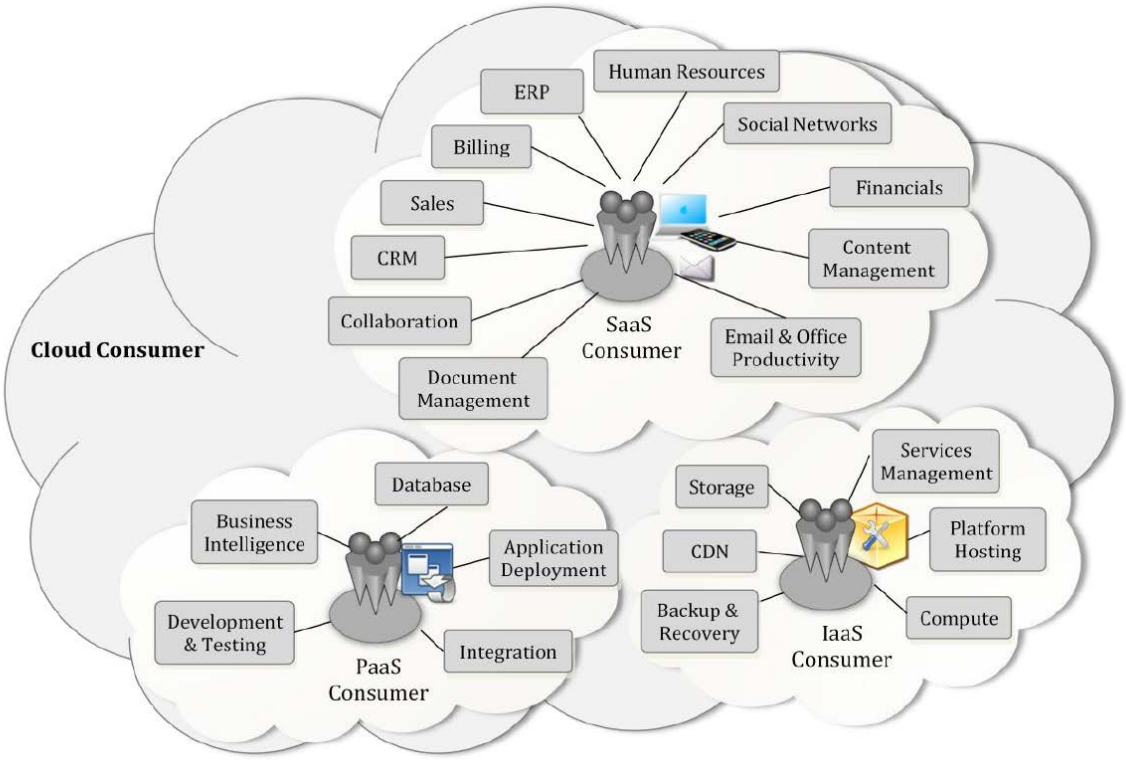

Figure 5 - Example Services Available to a Cloud Consumer – source NIST

Cloud clients

Users access cloud computing using networked client devices, such as desktop computers, laptops, tablets and smartphones. Some of these devices - *cloud clients* - rely on cloud computing for all or a majority of their applications so as to be essentially useless without it. Examples are thin clients and the browser-based Chrome book. Many cloud applications do not require specific software on the client and instead use a web browser to interact with the cloud application. With Ajax and HTML5 these Web user interfaces can achieve a similar or even better look and feel as native applications. Some cloud applications, however, support specific client software dedicated to these applications (e.g., virtual desktop clients and most email clients). Some legacy applications (line of business applications that until now have been prevalent in thin client Windows computing) are delivered via a screen-sharing technology.

2.2.3 Cloud Deployment models

Deployment models broadly characterize the management and disposition of computational resources for delivery of services to consumers, as well as the differentiation between classes of consumers.

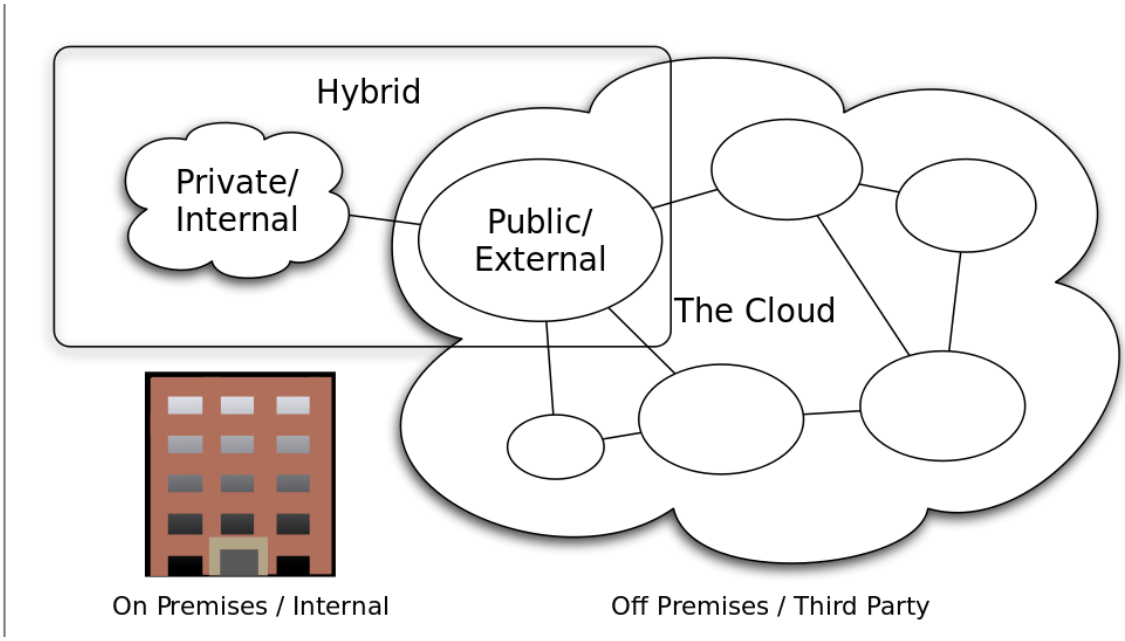

Figure 6 - Cloud computing deployment models – source Wikipedia

For most businesses, organizations, or governmental agencies, there are three relevant types of clouds: Private (internal or vendor-hosted), Public (external), and Hybrid (mixed). Each cloud infrastructure has unique characteristics and offers different advantages and disadvantages.

Enterprise Private Cloud

A private cloud enables enterprises to implement cloud technologies at their site and behind the firewall. Enterprises are implementing a private cloud within areas of their infrastructure in which a cloud model makes the most sense. A private cloud provides many of the benefits of cloud computing without the loss of control and security risks associated with other cloud infrastructure models. A private cloud includes virtualization technology to enhance scalability, resource management, and hardware utilization. In addition, it incorporates data centre automation of provisioning and chargeback metering for consumption and services-

based billing capabilities. Identity-based security protocols ensure that only authorized personnel have access to appropriate applications and infrastructure.

An increasingly popular version of a private cloud is a vendor hosted private cloud, sometimes referred to as a partner cloud. With this alternative, the cloud is hosted within a vendor secure data center. Virtualized applications are moved to vendor data center servers, and the vendor uses its cloud enterprise support tools, testing technologies, and procedures.

Advantages/Disadvantages of Enterprise Private Cloud Infrastructure

A private cloud enables customers to leverage many of the benefits of cloud computing within its own data center facilities. This cloud infrastructure model is ideal for clients subject to stringent privacy restrictions (banks, government, etc.). However, a private cloud will provide little to no immediate cost savings due to the investments required in technologies.

A vendor hosted private cloud allows organizations to take advantage of cloud computing and vendor tools, techniques, and experience, while limiting security risks. In addition, a vendor hosted private cloud frees in-house resources and provides an immediate reduction in IT support costs by enabling consumption-based billing. It also eliminates future infrastructure CapEx, while freeing up internal capacity. In short, this cloud model permits users to leverage vendor cloud methodologies, tools, and lower prices. However, it does not provide the optimum promise of cloud computing such as the lowest price and unlimited elasticity to ramp resources.

Public Cloud

In a model similar to electric utilities, a public cloud enables organizations to use infrastructure and applications via the Internet that reside in the cloud. This shared pool of networks, servers, storage, applications, and services are available to multiple people or enterprises. End users without actually possessing these resources can gain access to them easily on demand via a Web browser from a simple laptop or terminal, wherever they are needed and with minimal management or service provider effort. A well-known consumer version of a public cloud application is the iTunes Store.

Advantages/Disadvantages of Public Cloud Infrastructure

Since it is a shared capability, a public cloud is the lowest-cost cloud computing option. It provides an ideal platform for rapid proofs of concept (POC), on-demand performance testing, and document and information collaboration through technologies such as Microsoft SharePoint. The major downside of this cloud computing model is the location and security of proprietary information. One issue is that vendor cloud administrators have access to data creating theft or abuse risks. The location of data is also of great consequence since it determines under which laws the information resides. Another major concern is data recovery. Most public cloud servers are not built for high availability or automatic failover. As a result, enterprises may be forced to spend additional monies for a backup or failover environments. In addition, because of the utility nature of the public cloud model, vendors cannot provide meaningful Service Level Agreements.

Hybrid Cloud Infrastructure

A hybrid or mixed cloud environment provides the best of both worlds - combining elements of private and public cloud infrastructures. Within this model, a public cloud is leveraged to extend or supplement an internal cloud. For example, a company may employ an internal cloud to share physical and virtual resources over a network, but extend these capabilities when needed such as at peak processing times. Implementing a mixed cloud infrastructure enables enterprises to pick and choose which applications within the portfolio reside on a public versus private cloud. For example, this model permits financial applications with the most proprietary information to remain behind a firewall, while other software such as collaboration, customer service, or supply chain can reside on a public cloud.

Advantages/Disadvantages of Hybrid Cloud Infrastructure

A mixed cloud infrastructure model supports high capacity time periods and mitigates security risks on mission critical applications. It enables you to leverage the advantages of public cloud for more portable and appropriate applications, while maintaining control over legacy and vital systems with greater compliance, performance, and security requirements. The hybrid model also provides an optimal approach for architecture since organizations can combine local infrastructure with infrastructure that is scalable and provisioned on demand. Accordingly, a mixed model offers substantial cost savings at the same time as enabling

almost unlimited flexibility. It is important to note, however, by using this model enterprises are trading additional cost savings for added security.

Because of these considerable advantages, a hybrid cloud model is likely to be the most widely adopted infrastructure for global enterprises. The biggest drawback to this model is the complexity of monitoring and managing all portions of the hybrid cloud from a common portal or service desk. This requires considerable engineering on the part of the IT organization or the acquisition of third-party vendor services to provide the necessary "glue" to oversee the enterprise environment wealth of information on how to enhance their business value while reducing costs and freeing resources for more strategic initiatives. Implementing Keane's prioritized Applications Rationalization recommendations will provide immediate, quantifiable results, maximizing the return on your improvement investments.

Figure 7 below captures the deployment models, service models and characteristics of Cloud computing:

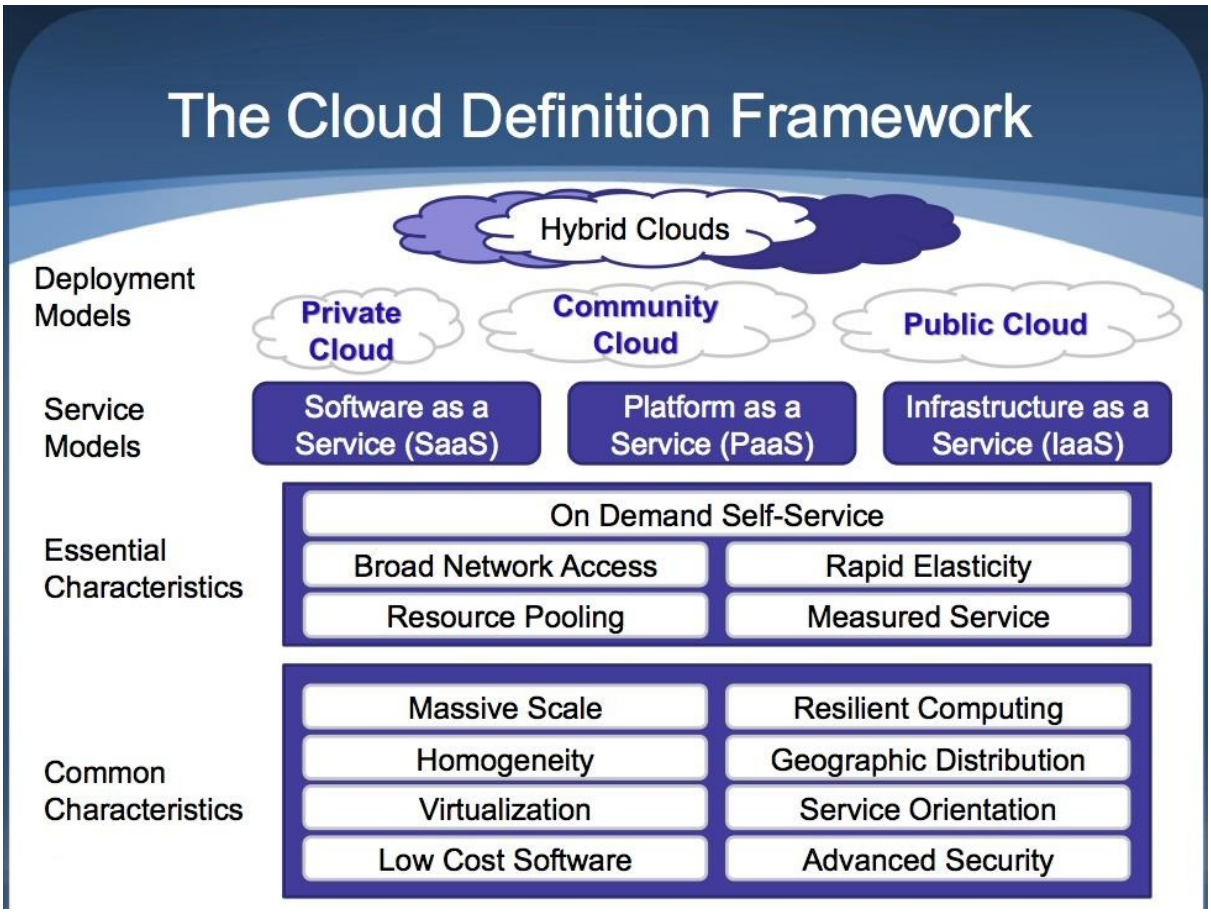

Figure 7 – The Cloud definition framework – source http:// kb.esds.co.in/a-framework-for-cloud-computing/

2.2.4 Benefits of Cloud computing

Location Independence

In a cloud based computing environment you access your data through an end terminal by punching in an identification key or password. You may use this password on any machine. Since the data does not reside on a specific end user (EU) terminal, the end user does not have to worry about a corrupt hard disk or a faulty RAM. You will not lose your data even if your machine breaks down. Think of this as signing into Facebook or Gmail from your friend's computer when yours breaks down.

High Availability

Most cloud based services implement DR (Disaster Recovery) and Business Continuity Plans (BCP) solutions that back up the user data. This means that even if the primary server is down, or is brought down for maintenance, the backup system still serves the EUs. Also, it is safe to assume that most cloud based services are run from world class Datacentres, thus minimizing the risk for any kind of downtime in the first place.

No Updates

Since applications too reside on service providers servers, that's where all the updates are implemented. In other words any operating system (OS) or application patches, new versions or any other kind of changes that need to be implemented, are responsibility of the service provider. EU always gets the latest version (well, in case of a paid service you might be asked to pay for the latest features but at least security updates and patches are automatically taken care of!)

No need for an Antivirus

As the data resides on service providers they implement security solutions to protect the data.

Lower computer costs

You don't need a high-powered and high-priced computer to run Cloud computing's web-based applications. Since applications run in the cloud, not on the desktop PC, your desktop PC doesn't need the processing power or hard disk space demanded by traditional desktop

software. When you're using web-based applications, your PC can be less expensive, with a smaller hard disk, less memory, more efficient processor, and the like. In fact, your PC in this scenario doesn't even need a CD or DVD drive, as no software programs have to be loaded and no document files need to be saved.

Improved performance

With fewer bloated programs hogging your computer's memory, you'll see better performance from your PC. Put simply, computers in a cloud computing system boot and run faster because they have fewer programs and processes loaded into memory.

Reduced software costs

Instead of purchasing expensive software applications, you can get most of what you need for free. That's right—most cloud computing applications today, such as the Google Docs suite, are totally free.

Instant software updates

Another software-related advantage to cloud computing is that you're no longer faced with choosing between obsolete software and high upgrade costs. When the application is web-based, updates happen automatically and are available the next time you log into the cloud. When you access a web-based application, you get the latest version—without needing to pay for or download an upgrade.

Improved document format compatibility

You don't have to worry about the documents you create on your machine being compatible with other users' applications or operating systems. In a world where Word 2010 documents can't be opened on a computer running Word 2003, all documents created by web-based applications can be read by any other user accessing that application. There are no format incompatibilities when everyone is sharing docs and apps in the cloud.

Unlimited storage capacity

Cloud computing offers virtually limitless storage. Your computer's current 200 gigabyte hard drive is peanuts compared to the hundreds of petabytes (a million gigabytes) available in the cloud. Whatever you need to store, you can.

Increased data reliability

Unlike desktop computing, in which a hard disk crash can destroy all your valuable data, a computer crashing in the cloud shouldn't affect the storage of your data. That also means that if your personal computer crashes, all your data is still out there in the cloud, still accessible. In a world where few individual desktop PC users back up their data on a regular basis, cloud computing is the ultimate in data-safe computing.

Universal document access

Ever get home from work and realize that you left an important document at the office? Or forget to take a file with you on the road? That's not a problem with cloud computing, because you don't take your documents with you. Instead, they stay in the cloud, and you can access them whenever you have a computer and an Internet connection. All your documents are instantly available from wherever you are; there's simply no need to take your documents with you.

Latest version availability

Another document-related advantage of cloud computing: When you edit a document at home, that edited version is what you see when you access the document at work. The cloud always hosts the latest version of your documents; as long as you're connected, you're never in danger of having an outdated version.

Easier group collaboration

Sharing documents leads directly to collaborating on documents. To many users, this is one of the most important advantages of cloud computing—multiple users can collaborate easily on documents and projects. Because the documents are hosted in the cloud, not on individual computers, all you need is a computer with an Internet connection, and you're collaborating.

Device independence

Finally, here's the ultimate cloud computing advantage: You're no longer tethered to a single computer or network. Change computers, and your existing applications and documents follow you through the cloud. Move to a portable device, and your apps and docs are still available. There's no need to buy a special version of a program for a particular device, or to save your document in a device-specific format. Your docs and their apps are the same no matter what computer or other device you're using.

Better return on investments (ROI)

Assuming similar IT asset returns on both Cloud and on-premise IT, it makes sense to go with Cloud's pay-as-you-go model where cost is incurred in the same period that the value is delivered (James Staten, 2009).

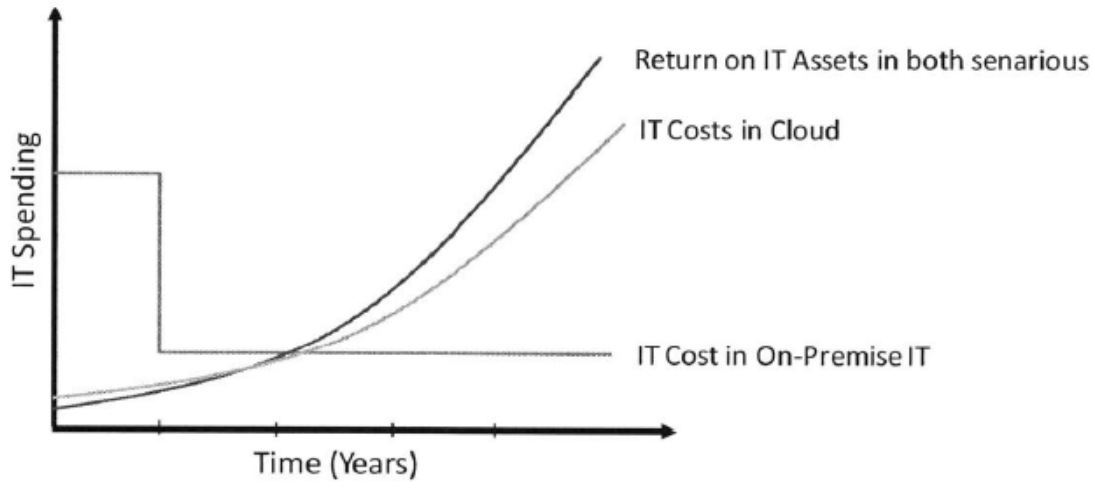

Figure 8 - Comparison of return on IT assets between traditional on-premise and Cloud

2.2.5 Limitations of Cloud Computing

There are many benefits of cloud computing irrespective of the size of the organization. The benefits include secure and affordable managed hosting, accessibility of data from anywhere at any time, offsite backup, no need of internal IT resources, scalability and so on. Tarun Juneja (2011) talks about the following limitations of Cloud computing which is still an evolving technology. Some weaknesses of cloud computing are:

Cascading effect

If there is a problem in data centre, all virtual machines are affected. There might or might not be a backup of the data if an enterprise relies only on the cloud for its data management needs.

Network connection

The concept assumes that the client has reliable network connection. If there are problems of network connectivity, accessing the cloud also becomes a problem. Performance of the cloud applications also depends on the performance of network at clients' side. Upload and download speeds are slower as compared to that of a local server.

Control of data security

In a public cloud model, the client does not have the control over security of his/ her own data. The clients' data can be susceptible to hacking or phishing attacks. Since the servers on cloud are interconnected it is easy for malware to spread.

Additional costs

Although cloud computing offers cost benefits, it has some hidden or additional costs as well. Clients are charged extra for data transfer or other services. Initial offerings are priced higher, until economies of scale work out for the service provider.

Peripherals

Peripheral devices like printers or scanners might not work with cloud. Many of them require software to be installed locally. Networked peripherals have lesser problems.

Integration

Integrating internal applications with those on cloud can be complex and in some cases not viable.

Generic

Public cloud offerings are very generic and offer multi-tenancy service which all organizations might not be comfortable with. Implementing an in-house cloud is more complex to implement and are burdensome on internal resources if the organization is not large enough.

Data Security

Now from Sony to Google, various corporations have at various times come out in the open about their services being hacked and user data compromised. In a cloud based environment this threat takes on a whole new meaning as by definition cloud computing does not allow any data including the most private and confidential documents to remain off the net!

Ownership

Did services like Facebook, Yahoo, Google, Dropbox etc. exist a quarter of century back? No. Did businesses exist? Yes. Did personal files exist? Yes. Imagine that you give up your desktop in favour of a Chrome book and a decade from now Google decides that since bottom line is not as good as what it used to be, they would be closing down the service. What do you do? There isn't much you can do but hope that someone would see this situation as an opportunity for business and offer a (very costly) migration to their service. And this is just one such scenario!

Bandwidth Dependence

In case your network in down or your data card doesn't work when you are travelling you lose all your data until the time you can connect to the Internet again.

Requires a constant Internet connection

Cloud computing is impossible if you can't connect to the Internet. Since you use the Internet to connect to both your applications and documents, if you don't have an Internet connection

you can't access anything, even your own documents. A dead Internet connection means no work, period—and, in areas where Internet connections are few or inherently unreliable, this could be a deal-breaker. When you're offline, cloud computing simply doesn't work.

Doesn't work well with low-speed connections

Similarly, a low-speed Internet connection, such as that found with dial-up services, makes cloud computing painful at best and often impossible. Web-based apps require a lot of bandwidth to download, as do large documents. If you're laboring with a low-speed dial-up connection, it might take seemingly forever just to change from page to page in a document, let alone to launch a feature-rich cloud service. In other words, cloud computing isn't for the broadband-impaired.

Can be slow

Even on a fast connection, web-based applications can sometimes be slower than accessing a similar software program on your desktop PC. Everything about the program, from the interface to the current document, has to be sent back and forth from your computer to the computers in the cloud. If the cloud servers happen to be backed up at that moment, or if the Internet is having a slow day, you won't get the instantaneous access you might expect from desktop apps.

Features might be limited

This situation is bound to change, but today many web-based applications simply aren't as full-featured as their desktop-based brethren. For example, you can do a lot more with Microsoft PowerPoint than with Google Presentation's web-based offering. The basics are similar, but the cloud application lacks many of PowerPoint's advanced features. If you're a power user, you might not want to leap into cloud computing just yet.

Stored data might not be secure

With cloud computing, all your data is stored on the cloud. How secure is the cloud? Can unauthorized users gain access to your confidential data? Cloud computing companies say

that data is secure, but it's too early in the game to be completely sure of that. Only time will tell if your data is secure in the cloud.

Stored data can be lost

Theoretically, data stored in the cloud is unusually safe, replicated across multiple machines. But on the off chance that your data goes missing, you have no physical or local backup. (Unless you methodically download all your cloud documents to your own desktop—which few users do.) Put simply, relying on the cloud puts you at risk if the cloud lets you down.

2.2.6 Who Benefits from Cloud Computing?

Which types of users are best (or least) suited for cloud computing? Given the pros and cons of cloud computing, the following types of users can benefit most from switching to cloud-based applications:

- Collaborators. If you often collaborate with other people on group projects, you're an ideal candidate for cloud computing. The ability to share and edit documents in real time between multiple users is one of the primary benefits of web-based applications; it makes collaborating easy and even fun.
- Road warriors. When you work at the office one day, at home the next day, and in another city the day after that, it's tough to keep track of all your documents and applications. With cloud computing, you don't have to remember which document is where or bring a copy of a document with you. You don't even have to worry about whether a particular application is installed on all your PCs. Since the apps and docs you use are stored on the Web and accessible wherever you have an Internet connection, versioning and compatibility simply aren't issues. You have the same applications and the same documents wherever you go.
- Cost-conscious users. Cloud computing can save you money on both hardware and software. There's no need to invest in large hard disks or super-fast CPUs; since everything is stored and run from the Web, you can cut costs by buying a PC with fewer features. You can save just as much (or even more) on software; instead of laying out big bucks for the latest versions of Microsoft Office, for example, you can use Google Docs or Zoho Office for zero expenditure. When your budget is tight, "free" is a lot better than the hundreds or thousands of dollars you might spend otherwise.
- Users with increasing needs. Need more hard disk space to store all your digital photos and MP3 files? You could purchase a new external hard drive, or you could utilize lower-cost (or free) cloud storage instead. Having trouble running the latest version of your favorite power-hungry software program? Abandon that power-sapping program and use a less-demanding web-based app instead. In the old days, the only solution to increased needs was to purchase more powerful hardware. With cloud computing, the solution is in the cloud—which saves you money.

2.2.7 Who Shouldn't Use Cloud Computing?

Below is a list of users that are encouraged not use Cloud computing:

- The Internet-impaired. Cloud computing is based on the Internet cloud and depends on Internet access. If you don't have Internet access, you're out of luck. Users without readily available Internet access simply shouldn't consider a switch to cloud-based computing. The same rule applies if you have slow Internet access, like that found with dial-up Internet connections; a slow connection isn't much better than none at all when accessing big apps and docs on the Web.
- Offline workers. Along the same lines, anyone who consistently works offline in an environment that's not Internet-enabled probably isn't the ideal candidate for cloud computing. That leaves out those people who work out of a vehicle, at a home or office without Internet access, or while traveling from office to office without guarantee of an Internet connection. No Internet, no cloud computing—it's that simple.
- The security-conscious. Today, we think that cloud computing is safe—but we can't guarantee it. It's certainly possible that cloud systems can be hacked and cloud-based documents accessed by unauthorized users. If your documents require confidentiality, you probably don't want to trust them to cloud computing just yet. When security matters, don't take chances.
- Anyone married to existing applications. This is probably the most important reason not to sign up for a web-based application: You use Microsoft Office. That's right, many web-based applications are not completely compatible with Microsoft's file formats. It may be difficult or even impossible to open your Word or Excel documents with your web-based apps—and vice versa.

2.3 Use of ICT in Agricultural Research Institutions

As ICTs have developed and become more pervasive, they have become more relevant in agricultural innovation systems. The most pertinent developments for research, extension, and e-learning are reviewed briefly below.

First and foremost, the increased pervasiveness of telecommunication networks has enabled ICT to reach rural areas. Technologies that have long been applicable to poor agricultural communities have not been effective simply because they are difficult to get into the hands of rural users. Expanded telecommunications networks have increased the speed, reliability, and accuracy of information exchange—through text, voice, and applications—between farmers and other stakeholders. Low-bandwidth networks have also started to trickle into rural areas in developing countries, creating opportunities for farmers to connect with extension workers, agribusiness, researchers, and each other. For example, telecommunications networks have facilitated e-learning by liberating it from the classroom and from the need for the user to invest in anything other than a mobile phone. Power lines and power sources critical for the regular use of and upkeep of ICTs also continue to expand.

Second, cloud computing services have immense potential to improve agricultural innovation systems. The advantage of cloud computing is that it offers pooled and elastic resources on demand over the Internet (Porcari 2009). More specifically, cloud computing has been described as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Mell and Grance 2009). Over the past few years, these services have created opportunities for data sharing initiatives that were once prohibitively expensive for most institutions to explore, let alone students conducting masters or doctoral research. They have also eased the data collection and aggregation process, which is critical for research, extension, and education. For example, a website such as Amazon Web Services can be used to acquire a Windows or Linux server by specifying how much processor, bandwidth, and storage capacity are needed. The required resource is made available immediately over the Internet, and the cost is based on how long the server is used. Cloud computing's elasticity and variable capacity make it possible to process very large datasets, which can also be shared with anybody with adequate internet connectivity.

Third, the movement toward open access and public involvement through online or mobile tools also favors agricultural innovation, not only in research institutions but more broadly among all participants in an innovation system. Governments, organizations, and even the private sector are sharing data and reports with the public and one another through ICT. As ICT has alleviated the difficulties inherent in interactions among people in dispersed locations, knowledge sharing and multi-stakeholder engagement are widely acknowledged to have increased. Research can involve more expert opinion and diversity. Advisory services can tap a much wider range of current expertise and provide advice in a much more targeted way to those who need it. With Internet access, e-learning can occur even in the absence of a formal distance education program, and web platforms such as agropedia, make it much easier to develop and transmit content for e-learning programs.

New forms of knowledge brokering have been made possible through ICT. Knowledge brokering has always been an integral part of agricultural innovation systems. The creation and passing of information between farmers and extension agents, farmers and researchers, and researchers and extension agencies, among others, is critical to innovation and increased productivity through adoption of better farming practices and technologies.

Knowledge brokering is becoming a specialization—sometimes a profitable one. On a more basic level, as digital literacy and the availability of ICTs increase, farmers, traders, and others in developing countries are offering information services for a small fee. This private activity can widen the availability of information in rural areas and reduce pressure on public extension agents, who are charged with getting timely and locally relevant information to farmers. Private sector involvement in advisory services has almost always been more successful than the involvement of public services with their very broad mandates, but until recently the high costs of such services limited private advisory initiatives. An issue that policy makers need to examine, however, is how public advisory services and other forms of knowledge brokering will meet the needs of rural people who are not linked into the innovation system through ICT, either because they cannot access it or do not yet know how to use it effectively.

2.4 Migration to the Cloud

Once an enterprise has made a decision to allocate part of its budget to explore the Cloud space or bring in a brand new service from the Cloud to the enterprise, what are the frameworks they should follow? What qualification criteria they should look for Cloud adoption, what applications or areas of their business they should move to Cloud, what areas should they leave on-premise for now and they should define their short and long term Cloud strategy. Cloud space brings a lot of opportunities but different enterprises and industry domains will have their unique drivers and constraints for Cloud computing adoption (Ashok Dhiman 2010). To answer these questions and many others, (Ashok Dhiman 2010) outlines the processes and frameworks that enterprises can adopt to make a smooth transition to the Cloud.

In this section we look at the decision framework, migration framework, the migration strategy, migration path, planning and implementation, IT Operations strategy during implementation and the feedback loop after migration to the Cloud.

2.4.1 Decision Framework

Decision frameworks adopted by various enterprises will depend on hard factors like cost savings, performance benefit, and soft factors like agility in the enterprise IT, culture of the company, competitive landscape, etc. At a high level there will be some sort of steering committee which will comprise of key stakeholders in the organizations. They will work on the business case of going to the Cloud. Once the Cloud migration strategy is in place, the readiness of organization and its applications to move to Cloud will be assessed through pilots and prototypes. The results of pilots and readiness testing will drive the approval from sponsors of the Cloud migration initiative. A Cloud migration decision framework might look like the one in figure 9 although it might differ in approach by IT departments in different enterprises. This generic Cloud migration decision framework consists of the following steps from creation of Business case to approval:”

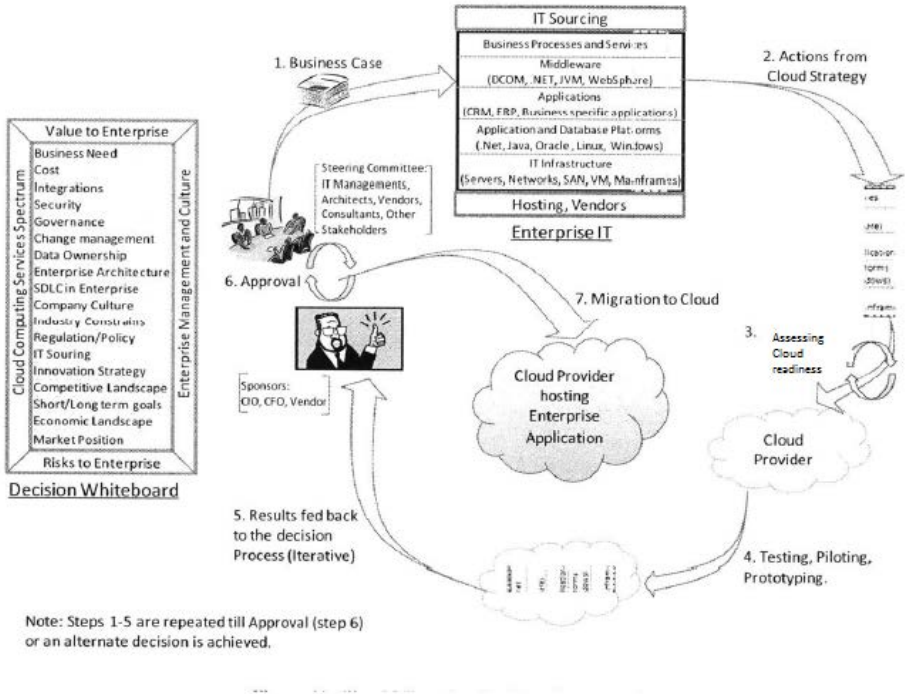

Figure 9 : Cloud migration decision framework – source Ashok Dhiman (2010)

In a given enterprise the Cloud migration initiative is likely to come from a set of sponsors in senior management. They might either form a loosely managed group of folks from different areas to assess readiness or may create a more formal group like steering committee which will work with business and sponsors to drive the Cloud migration strategy.

1. Creation of Business case: The very first step before a big business initiative like moving on-premise applications to Cloud would be the creation of business case. A business case will include all the metrics indicating financial performance and key business benefits which will give clear reason to move (or not) to Cloud. An important part of the business case will be setting of a baseline for assessing the impact of the investigation and estimating high level costs and resource requirements.
2. Cloud migration strategy : Once the business case is in place the next steps would be to come up with a Cloud computing migration strategy by aligning the investigation with the business strategy, and show how it can deliver business value. Show how the investigation might lead to changes that will affect business and the IT architecture environment. An important part of the strategy will be to work with key stakeholders to identify business needs.

3. Assessing Cloud readiness: Next, evaluate which cloud computing models, architectures, technologies and best practices will make sense to implement (e.g. Private, Public or hybrid Cloud) in your enterprise setting. Also assess the budgetary, resource and technical requirements necessary to prepare the business for pilot/ testing phase of investigation. From financial perspective develop a total cost of ownership analysis and review established policies for assessing risks and change management. There are many tools available which one can use to get to numbers quickly, like ROI calculator at http://www.getapp.com/Cloud-computing-roi-calculator which allows you to calculate costs for IT infrastructure, development costs, projects, IT services costs on-premise and see, with average % reduction how much an organization can save in Cloud.
4. Testing, Piloting and Prototyping: Identify the application/business processes within enterprise which will be good candidates for testing / piloting in the Cloud. For most organizations these will be non-mission critical applications yet important ones to be able to show performance and cost benefits.
5. Results / Observations: Develop and implement the pilot/prototype and communicate the results. Note down any specific observations which might be of interest to the iterative decision making process.
6. Feedback to Decision process: Steering committee will analyze the findings of readiness assessment and pilot/prototype effort. Depending on the results they might revise the strategy and business case creating subsequent iterations in the decision process. Results and findings are also presented to senior management, key stakeholders and business leaders to get their inputs and direction.
7. Decision: Depending on the assessment outcome, steering committee might work with sponsors to make a decision for or against Cloud computing migration. Decision might include parameters like choice of Cloud architectures, applications to migrate, change in business process and their management, etcetera.

Decision making process will also include factors such as:

- Sourcing strategy
- Enterprise architecture
- Relationships with vendors and business partners
- Company culture pertaining to IT innovation and adoption by business.

Decision process is a required step to customize the Cloud adoption to a given enterprise – understand the Cloud computing trends and assess what are their possible impacts on business objectives, strategies and processes. Assessment will indicate what should change – and what needs do not change – and a tentative timeframe for those changes (Dreyfuss Feb 2010).

2.4.2 Migration framework

Once the decision has been made to move to Cloud, there are still important steps which should be followed to achieve a smooth transition. Enterprise needs to come up with migration strategy and plan before they can actually implement the business process in Cloud. Also important is feeding back the learning from implementation for future migration decision and is essential to the whole migration framework.

2.4.3 Migration Strategy

Migration strategy involves finding and understanding various Cloud migration options available to an enterprise. Look at the business priorities and work on a strategy that offers a balance between the migration costs and getting needed business benefits in time. This also involves looking at all the internal and external technology and business dependencies and deriving the most optimal way from the available options. Migration strategy should include discussion on data integration, change management of business processes, outsourcing, user training, documentation and architectural implication.
Cloud migration strategy should be in place even if there is no immediate need for Cloud migration. This will help enterprises to get on quickly with migration plans if the need is identified in the future decision processes.

Various parameters influence each other, these include decision framework and the migration strategy as the key factors. For example, the need for customization of a Cloud offering which will replace on-premise application might affect the costs as well as Cloud migration options, which in-turn affects the migration framework and strategy. The parameters might differ depending on the IT implementation of a given enterprise but this gives a sense of how various parameters interact with each other to influence the migration strategy.
Apart from the Decision framework and the migration strategy, the other influencing factors would be the business case, and selection of a cloud provider,

2.4.4 Migration Path

Depending on the migration strategy enterprises have following three options with a Cloud infrastructure – private, public, and hybrid. Within each of these options they have the migration paths of – IaaS, SaaS or PaaS (see fig 10 below). The choice is driven by business priorities such as economics, scalability, on-demand provisioning, and pay-as-you-go model and constrained by factors such as security, migration costs, existing IT investments, etc. Enterprises also have an option to leverage a hybrid approach in which they can mix and match migration paths depending on business criticality and security concerns of a given application or business process.

In the spectrum of Cloud offerings, the relative standardization and cost effectiveness increases as you go from private to Hybrid to Public option. So a Private option can give you benefits like ownership of data and perceived security but it might cost you more than a public cloud option. In the current environment, even though the benefits of moving to Cloud computing are clear, the security and data ownership fears are making enterprises slow down on making a complete shift to the Cloud – Private Clouds fill this gap by providing the economics and giving control of data and security to enterprise IT.

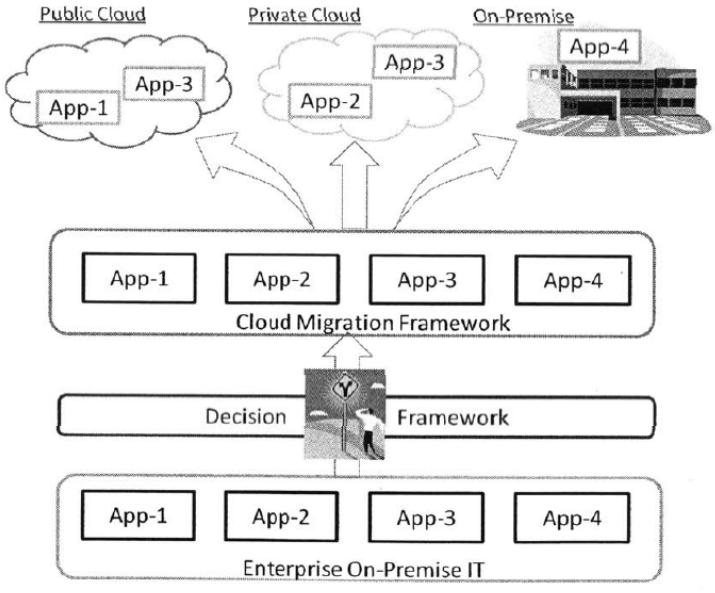

Figure 10: Cloud Migration paths for enterprises – Source Ashok Dhiman (2010)

Table 1 below shows more detail about Private, Public and Cloud implementations and their comparison. Cost savings and degree of "standardized applications and services" increases as you go from Private Clouds to Public Cloud. The degree of sharing between Cloud tenants increases as you go from Private to Public Cloud. Private Cloud (Internal Cloud) is ideal for organizations that are risk averse and have sensitive data which they do not want to see outside their enterprise perimeter. Hosted Clouds (Hybrid) is good first step for non-critical applications or good second step for critical applications after an organization has gained enough experience and confidence from Cloud to take it to the next level. Public Cloud offers maximum cost savings and performance benefits and might be only type of Cloud in future but till it matures to that extent, the enterprise will use Private and Hybrid as part of their Cloud migration strategy.

	Public cloud	Hosted Cloud	Internal Cloud
Where it resides	Internet – connected data centers	Internet – connected data centers	Corporate Data center
Tenancy model	Multiple clients	Multiple clients	Single company
VMs reside on	Shared infrastructure	Dedicated but hosted infrastructure	Dedicated infrastructure
Security model is	Common across all customers, with limited configurability	Common across all customers, with greater configurability	Unique to the customer
Cloud managed by	Provider	Provider or IT ops	IT ops
Infrastructure managed by	Provider	Provider	IT ops
Billed by	Consumption	Monthly for dedicated infrastructure, excess billed by consumption	Consumption-based metering for BU chargeback or allocation

Table 1 : Cloud migration paths for enterprises – source Forrester Research Inc.

2.4.5 Planning and Implementation

Once a migration strategy is in place it should drive the planning and implementation phase of Cloud migration. During migration planning, understand the variables and their effect on the business process. Categorize and prioritize the variables in the bins which will make it easier to deal with them during implementation. At the enterprise level, make sure to involve the stakeholders early in the process so that they have vested interest in the success of Cloud migration. Identify the dependent upstream/downstream applications and processes and facilitate clear communication through a well-documented communication plan. Buy in support of stakeholders outside the organization (vendors and business partners), they should see the benefits of migrating applications to the Cloud instead of focusing on the challenges. In large enterprises with complex weave of systems and process, it is critical to involve the enterprise architecture group and make sure they are onboard with moving applications/business processes to the Cloud. Enterprise architects will also highlight any integration or architectural implications which might be costly in the long run.

IT services and operations should also be involved from early on to get their input on any support implications and anything additional they might have to support during the transition period. Early involvement will give IT operations the window to hire needed resources to support the migration of applications. In addition, there might be changes needed on the support process (helpdesk calls, SLAs, Knowledge base, etcetera) to make sure users continue to get service during migration phase. In new support model of Cloud computing, IT operations will also need to make sure Cloud providers are delivering what is agreed in SLAs.

Finally, during implementation make sure the testing, qualification/validation and back-out plans are in place. There might be challenges around moving and securing large amount of data to the Cloud. Check for up/downstream dependencies and performance pitfalls. Make a preferred Cloud provider list in place for various services needed by the enterprise and select providers that have already achieved success in the technologies and business processes your applications will use.

It is always recommended to take small group of applications and move them in a phased approach for better understanding and risk mitigation. During testing phase make sure proper

impact analysis (technical as well as business) is done. Depending on the success of testing, customize or package the applications/service for easy consumption by enterprise users. All affected users should be communicated to about the change and any training they need to go through (Chetan Kothari, 2010).

2.4.6 IT Operations strategy

In the new world of Cloud computing, IT support will have to consider Cloud as an extension of their on-premise capabilities and make sure they are onboard with new requirements to deliver required support and make sure Cloud providers deliver (through SLAs) same or better quality of service to business. Cloud gives instant access to computing resources for innovation in business but it can easily create a nightmare for the IT operations team. The fact that it is so easy to provision computing resources and integrate them with on-premise IT, users might add to the complexity of the systems used by enterprises. IT operations and enterprise architecture groups should be involved during these decisions to make sure the enterprise standards are followed and that applications are supported. For example, IT operations group and enterprise architect can agree on a limited agreed stack of technologies which can solve the enterprise's range of business needs (Golden, 2010). They can have mechanisms in place which let the stakeholders know easily the impact of new application and business process migration to Cloud on up/downstream applications and business processes.

2.4.7 Feedback loop

Once the application(s) has been migrated to Cloud, there are opportunities to learn from the implementation, user experience, vendor experience, performance metrics, cost savings and ROI. Feedback new found problems, new discovered risks and success stories to the migration strategy so that future Cloud adoption can be adjusted accordingly.

2.4.8 Interaction between the different players

Having discussed the different deployment models, Cloud architectures, cloud providers, consumers, and regulators, it is important for us to discuss how the different players interact to ensure that the service is delivered to the expectations of the Cloud consumer. Figure 11 below presents an overview of the NIST cloud computing reference architecture, which identifies the major actors, their activities and their functions in Cloud computing. The diagram depicts a generic high-level architecture and is intended to facilitate the understanding of the requirements, uses, characteristics and standards of cloud computing.

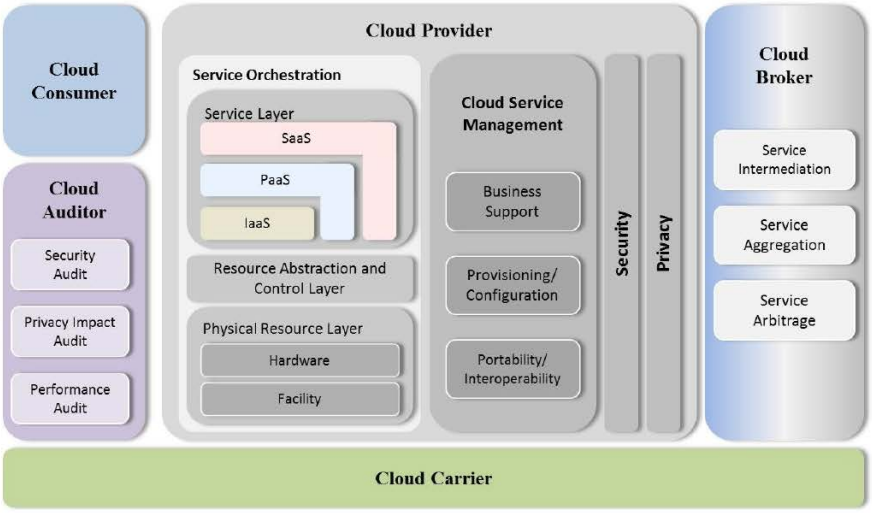

Figure 11 – The Conceptual Reference Model – Source NIST

Table 2 below gives a summary of the roles that the different actors play. Each actor is an entity (a person or an organization) that participates in a transaction or process and/or performs tasks in cloud computing

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

Table 2 - Actors in Cloud Computing – Source NIST

A cloud consumer may request cloud services from a cloud provider directly or via a cloud broker. A cloud auditor conducts independent audits and may contact the others to collect necessary information. Figure 13 below illustrates the relationship(s) between the actors in Cloud computing.

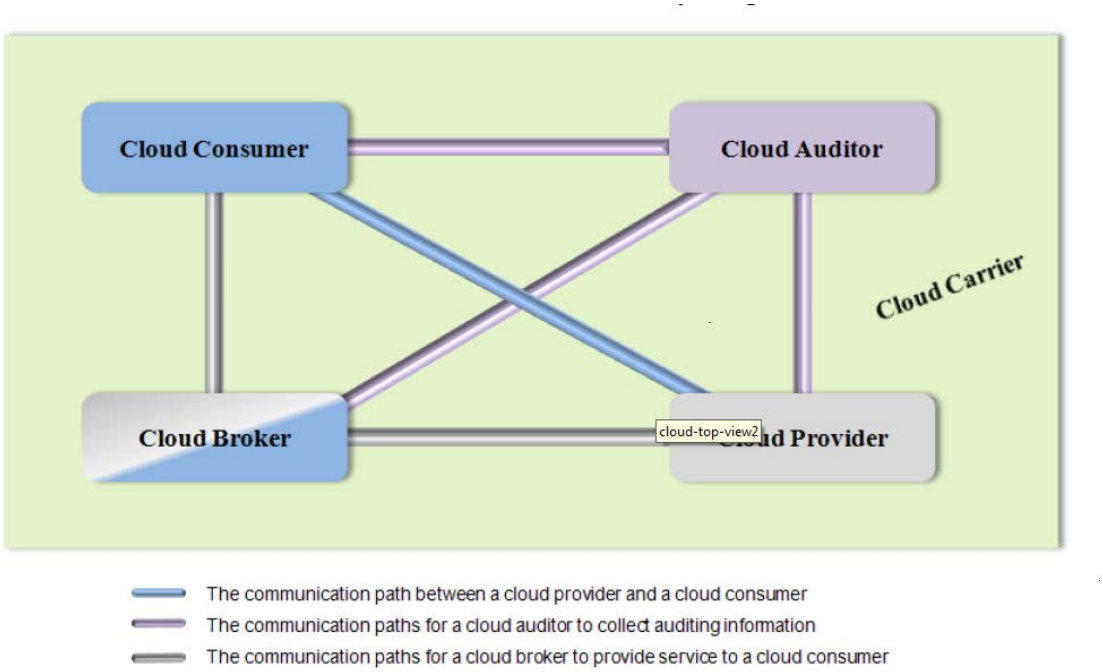

Figure 12 - Interactions between the Actors in Cloud Computing – Source NIST

A Cloud Provider's activities can be described in five major areas, as shown in Figure 13 below. A Cloud provider conducts its activities in the areas of service deployment, service orchestration, cloud service management, security, and privacy

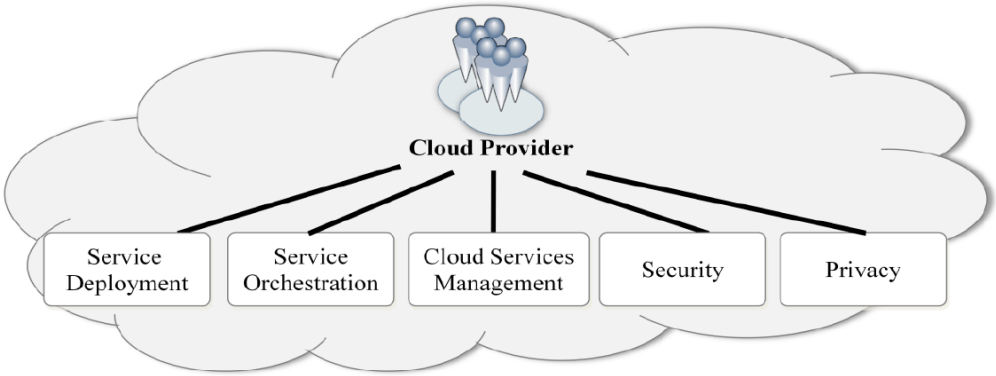

Figure 13 - Cloud Provider - Major Activities – source NIST

2.4.9 The Conceptual Model

It is important for us to understand the determinants of IT adoption and the theoretical models that have arisen addressing IT adoption. Researchers examine factors influencing the adoption of technology related products and services in different aspects and also using a variety of theoretical perspectives. Literature shows that the widely used models include:

- ✓ The technology acceptance model (TAM) (Davis 1986, Davis 1989, Davis *et al.* 1989),
- ✓ Theory of planned behavior (TPB) (Ajzen 1985, Ajzen 1991),
- ✓ Social Cognitive Theory (SCT) (Compeau & Higgins, 1995a, 1995b; Compeau *et al*., 1999; Hill *et al*., 1987)
- ✓ Diffusion on innovation (DOI) theory (Rogers 1995)

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) (Davis, 1989, Davis *et al*., 1989) is an extension of the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975). TRA is about an individual's behavior as a positive function of his/her behavioral intention to perform the behavior.

In order to gain a deeper understanding of the factors influencing behavior, it is required to look for the determinants of the attitudinal and normative components. Ajzen and Fishbein (1980) suggest that the determinants are beliefs individuals hold about themselves and their environment. Those beliefs are viewed as underlying an individual's Attitudes and Subjective Norms which ultimately determine an individual's behavioral intentions. The model explains that the behavior is influenced by the intention. The intention is influenced by Attitude and Subjective Norm.

In the TRA model, an Attitude towards a behavior consists of 1) a belief that particular behavior leads to a certain outcome and 2) an evaluation of the outcome of that behavior. This is to say that if the outcome seems beneficial to the individual, he/she may then intend to or actually participate in a particular behavior. For Subjective Norm, it is an individual's perception of what others around him/her believe that the individual should do. Whether or not an individual participates or intends to participate in any behavior is influenced strongly by other people around him/her. These people might be friends, classmates, family members,

colleagues, community, leaders, celebrities, and so forth.

The TAM model is presented in Figure 14. Davis (1989, p. 320) defines perceived usefulness and perceived ease of use as:

• Perceived usefulness is the degree to which a person believes that using particular system would enhance his or her job performance.

• Perceived ease of use is the degree to which a person believes that using a particular system would be free of effort.

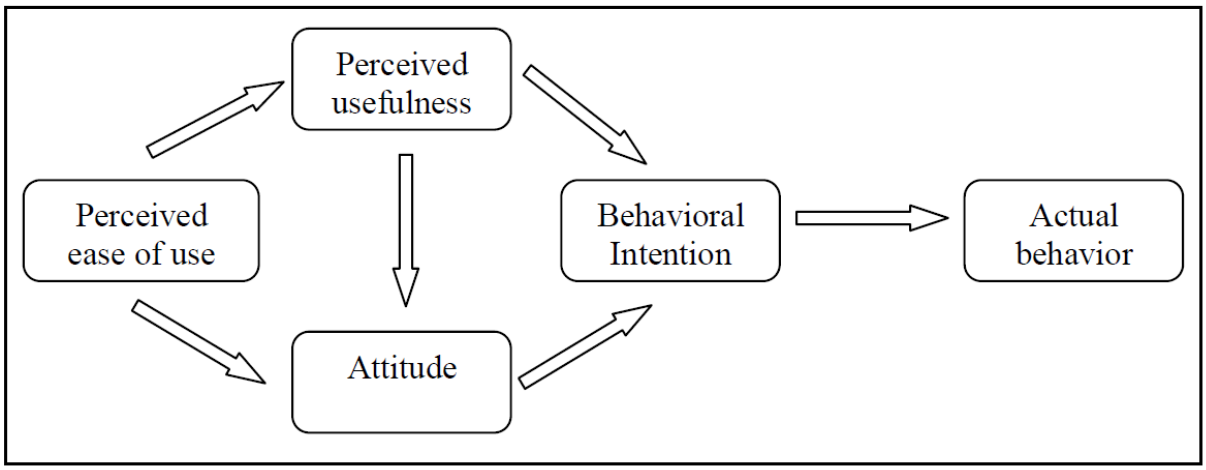

Figure 14 Technology Acceptance Model (TAM) – source Davis (1989, p. 320)

Since TAM was introduced, it has been the most influential and widely used model in predicting and explaining the usage behavior of technology related products/services. Nevertheless, it has been criticized for possible limitations since it emphasizes only the effect of technology. In fact, the behavioral intention of individuals is also influenced by other things surrounding them.

Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB) was also developed from the Theory of Reasoned Action (TRA). Ajzen (1985, 1991) extends TRA by adding perceived behavioral control to the original TRA mode as an additional determinant of intention and behavior. TPB claims that behavior is a direct function of behavioral intention which is determined by three factors; Attitude, Subjective Norm, and perceived behavioral control. Attitude and Subjective Norm are consistent with the original TRA model while perceived behavioral control refers to the individual's perception of his/her control over performance of the behavior. The TPB model is presented in Figure 15

Ajzen (1991) reviews several studies using the TPB model and states that Attitude, Subjective Norms, and perceived behavioral control are usually found to predict behavioral intentions with a high degree of accuracy. The TPB model can be used in several contexts. For technology adoption, TPB has been successfully applied to understand individual acceptance and usage of many different technologies (e.g. Harrison D. *et al.*, 1997; Mathieson, 1991; Taylor & Todd, 1995b). In this research stream, the twin model to TPB is the Decomposed Theory of Planned Behavior (DTPB) which was developed by Taylor and Todd (1995b). DTPB is a combination of TAM and TPB so that the main component of DTPB is the same as TPB but the Attitude factor is integrated with the TAM model.

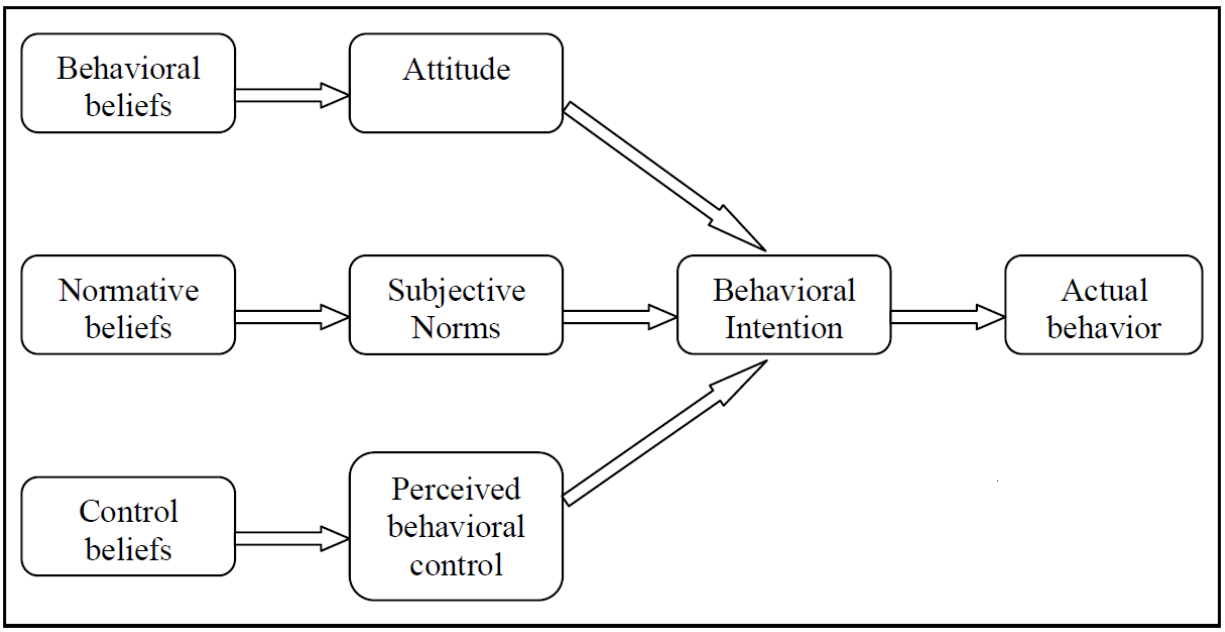

Figure 15 - Theory of Planned Behavior (TPB)

Social Cognitive Theory (SCT)

Social Cognitive Theory (SCT) was developed by Bandura (1986) who was influenced by the Social Learning Theory (SLT). The SCT evolved under the umbrella of behaviorism, which is a subset of psychological theories intended to explain why people and animals behave the way that they do. The SCT model is widely used to understand and predict individual and group behavior. According to the theory, Bandura (1986) views individual behavior as a triadic reciprocality consisting of personal factors, behavior, and environment. Individuals choose the environments in which they exist in addition to being influenced by those environmental factors, e.g. social pressures and unique situation. Moreover, behavior in a given situation is affected by environmental factors, which in turn is affected by behavior.

The last reciprocal interaction is that behavior is influenced by the individual's cognitive and personal factors, which in turn affects those same factors.

The SCT has been widely used in the area of public health services. Nonetheless, the theory is also applicable to predict an individual's behavior toward technology. Compeau and Higgins (1995a, 1995b) apply and extend SCT to the context of computer usage and adoption. They emphasize the role of cognitive factors within the original SCT model. There are two sets of expectations as the major cognitive forces guiding behavior. The first set relates to outcomes. Individuals are more likely to accept behaviors they believe will result in appreciated outcomes than those they do not see as having favorable outcomes. The second set of expectations is called Self efficacy, meaning the beliefs about one's ability to perform a particular behavior. Self-efficacy influences choices about which behaviors to accept, the effort and persistence exerted in the face of obstacles to the performance of those behaviors, and therefore the mastery of the behaviors.

The schematic of the model is presented in Figure 16.

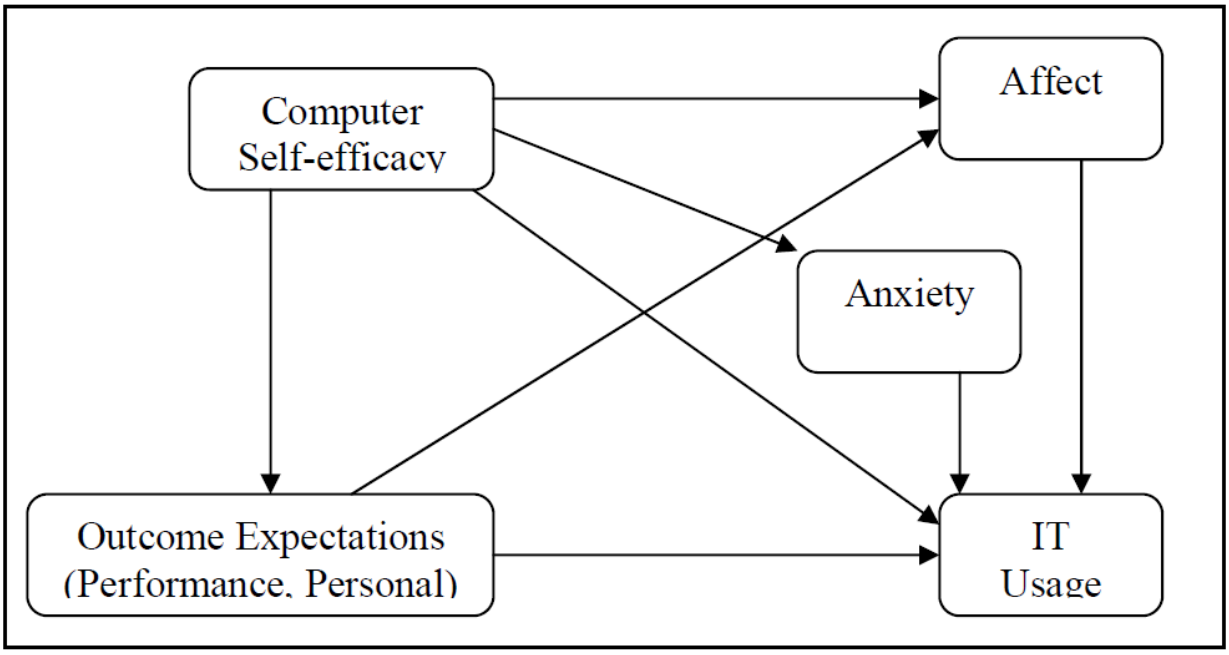

Figure 16 - IT usage based on the SCT concept

Diffusion of Innovation (DOI)

Diffusion of Innovation (DOI) is also known as Innovation Diffusion Theory (IDT). The DOI model was comprehensively developed by Rogers (1962, 1983, 1995, 2003) to explain how, why, and at what rate new ideas and technology spread through specific a group of individuals and organizations. DOI is defined as "the process by

which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1983, 1995). DOI has been widely used in several disciplines including sociology, anthropology, education, marketing, management, and others. The framework of innovation adoption process was introduced in 1962 and has been extensively cited in the literature since then. Rogers (2003) states that the adopters of any new innovation or idea can be classified into one of five categories: innovators, early adopters, early majority, late majority, and laggards. The innovation adoption process is presented in a bell curve in Figure 17.

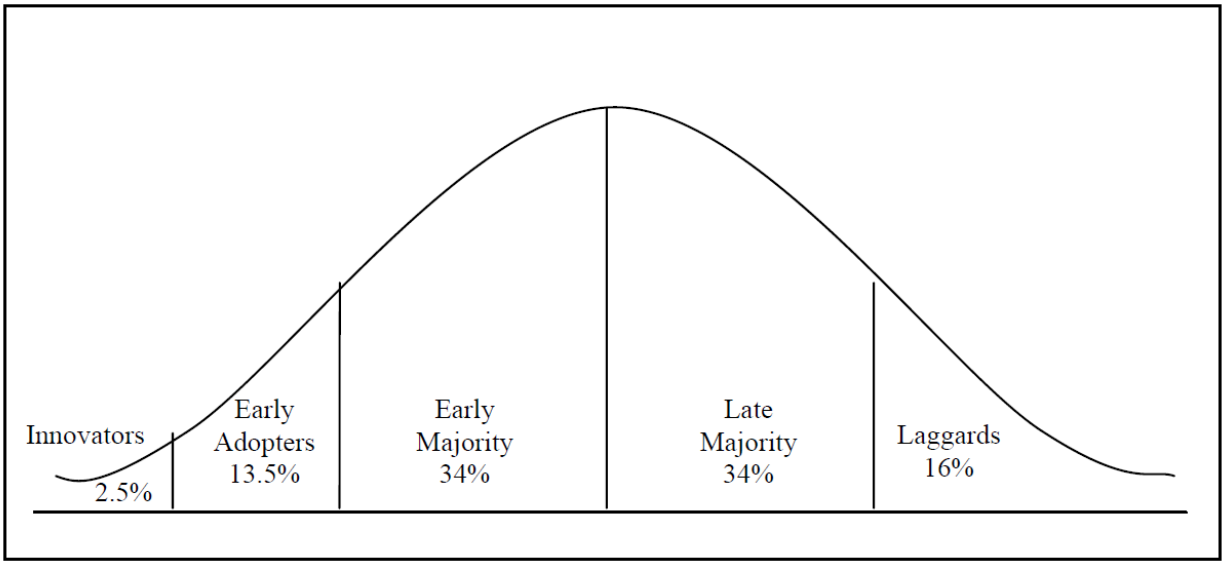

Figure 17 -The innovation adoption process (Rogers, 2003, p.281)

Innovators – They are brave people who want to be the first to adopt and display behavior, demonstrating that they are likely to be at the forefront of a particular innovative idea or process. They account for 2.5% of the adopter group.

• **Early adopters** – They are respectable people. They are also quick to adopt new ideas or processes but in a careful way. They tend to be opinion leaders since they are among the first to adopt the new thing. This group accounts for 13.5%.

• **Early majority** – They are thoughtful people. They think more carefully than the early adopter group but still accept change more quickly than the average. They tend to stand back and watch the experiences of others. This group accounts for 34%.

• **Late majority** – They are skeptical people who tend to adopt a new thing later than the average person. They are slower to catch onto the popularity of new ideas or solutions. They typically adopt a new thing when the majority is using it. Even they

are also a large group, but they adopt a new thing after its newness has worn off. They account for 34%.

• **Laggards** – They are traditional people who prefer the old traditional style. They are critical towards new ideas and will only accept it if the new idea has become mainstream or even tradition. This group accounts for 16%. For factors influencing the adoption of innovation, Rogers (1983, 2003) argues that innovation characteristics are primary determinant in the innovation adoption process.

Five attributes of innovation are determined: Relative Advantage, Compatibility, Observability, Complexity, and Trialability. Based on Rogers (2003), the detail of each attribute is described below:

• **Relative Advantage** refers to the degree a new innovation is perceived as better than current practices.

• **Compatibility** is the degree to which a new innovation is perceived to be consistent with the adopters' existing values, past experiences and needs.

• **Observability** refers to the extent that the results of an innovation are easily seen and understood.

• **Complexity** refers to the perceived difficulty of learning to use and understand a particular new innovation.

• **Trialability** is the degree to which an innovation can be experimented with or used on a trial basis.

The Conjunction of the Four Adoption Models

The four adoption models focus on the context of the individual and technology. However, in order to come up with a comprehensive research framework, we need to include other pertinent factors that can influence technology adoption. Tornatzky and Fleischer (1990) conceptualize that the context of technology adoption consists of three aspects; technological, organizational, and environmental. Their study is known as the technology-organization-environment framework. This framework has been reported to have a consistent relationship with adoption behavior (Carayannis & Turner, 2006; Jeon *et al*., 2006; Kuan & Chau, 2001;46

The framework may have some limitation since the characteristics of the manager or

policymaker are not included in the framework. An individual's personal characteristics might affect the adoption decision as well. This is especially true in the case of small firms where most business activities rely on manager/owner of the firm.
Seeing the aforementioned limitations, Thong (1999) expands Tornatzky and Fleischer's (1990) framework by adding individual characteristics and advises four characteristics that can influence technology adoption decision. The four characteristics are :

- management characteristics,
- technological characteristics,
- organizational characteristics,
- environmental characteristics

In this research study, management characteristics will be replaced by individual characteristics since the decision to adopt technology will be influenced by a team and not just a manager's view.
By combining the constructs from the four technology adoption models and the additional factors from the expanded model, we can summarize the main determinant factors under each of the four categories as:

Individual context

- Attitude
- Subjective norm
- Self-efficacy
- Innovativeness
- Technological experience

Technological context

- Perceived Advantage
- Perceived Easiness
- Compatibility
- Observability
- Trialability

Organizational context

- Financial Resources
- Technological Expertise

Environmental context

- Competitive Pressure
- Customer Pressure
- Industry Pressure
- Government encouragement
- External support – support from technology vendors

THE CONCEPTUAL MODEL

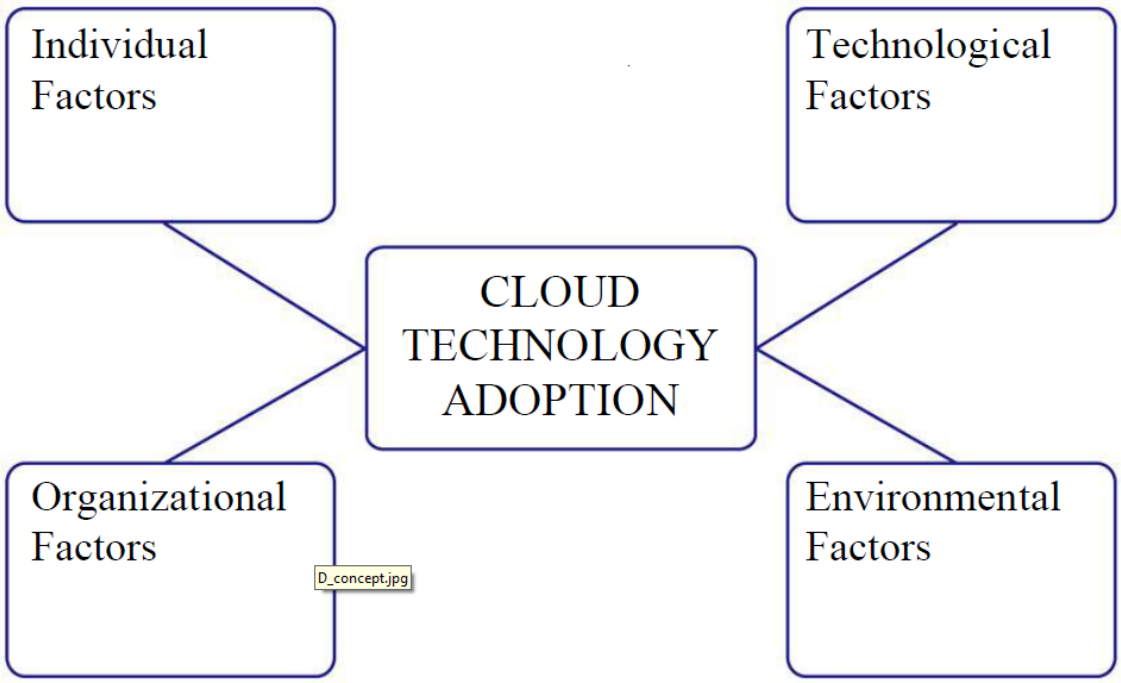

Figure 18 – The Conceptual model

2.4.10 Chapter Summary

This chapter started by looking at the features of the traditional on-premise computing. The features of Cloud computing were analyzed in detail. The different Cloud service models and Cloud deployment models were also reviewed. In this chapter we also look at the different groups of users that are suitable candidates for Cloud computing and also which categories of users are not to be advised to use Cloud services. Finally we looked at the various aspects of migrating applications to the Cloud and this includes: The decision framework, migration strategy, migration path, planning and implementation, IT Operations strategy, and the feedback loop. The four technology adoption models namely TAM, TPB, SCT and DOI were reviewed and finally a conceptual model to guide the research was designed.

In the next chapter, we shall look at the research methodology that will enable us to meet the objectives of the research.

3.0 RESEARCH METHODOLOGY

3.1 Research Design

A research design is the plan of a study used to guide the collection and analysis of the gathered data. According to McNamara (2000), there are three main types of research designs, namely: Causal research design, whose emphasis is to determine a cause-and-effect relationship; Descriptive research design, whose emphasis is to determine the frequency of occurrence of a certain phenomenon, or it explains the degree to which two variables co-vary; and Exploratory research design which emphasizes on gaining insights. It is useful in breaking vague or very broad problem statements into smaller, precise statements.

McNamara (2000) continues to state that there are four levels of information that can be gathered from customers or clients, including getting their - reactions and feelings; learnings; changes in skills; and effectiveness, in that order, and that the most useful research results are those targeting the effectiveness level of information. Unfortunately, it is quite difficult to reliably get information about effectiveness even though information about learning and skills is quite useful. McNamara, (2000) mentions the following as the different available data collection methods: Appreciative Inquiry, Case Study, Focus Groups, Interview, Listening, Questioning (face to face), Questionnaires and Surveys.

The research method selected should get the most useful information to key decision makers in the most cost-effective and realistic fashion. Since this was a study focusing on coming up with a migration framework for ACGs in Kenya, the selected method for research was case study owing to the unique and specific nature of the sector that is being investigated.
The case study analyzed Cloud computing and figured out the extent of use in ACGs in Kenya, challenges and opportunities. The study aimed to get a cross-sectional view of Cloud computing in ACGs. The target respondents were personnel within the ICT teams who are in charge of administration of IT software applications, the underlying infrastructure and the various end user access tools – desktops, laptops, tablets and smart phones.

3.2 The choice of the Case being studied

There are no known studies that have been carried out in Kenya to examine the current state of computing and to come up with Cloud migration frameworks for enterprises. Considering that Cloud computing is an emerging technology and organizations are yet to fully understand it, this can be the reason why there is no adequate information in the sector of study.

Appendix 6.1 gives a list of institutions in Kenya which have a relationship to or partnership in agriculture. The organizations are categorized into the following classes: CGIAR centers, NGOs, Regional and Eco-regional Organizations, International Organizations and NARS – Joshua Shivo (2010). This study will focus on CGIAR centers namely International Livestock Research Institute (ILRI) and World Agroforestry (ICRAF). The two centers have their head offices in Nairobi, Kenya. ILRI has ten regional offices and ICRAF has twenty four regional offices thus giving the organizations both local and international perspective.
The study focuses on respondents from the ICT department and other departments that work with ICT.

ILRI and ICRAF have a joint ICT team and this therefore made data collection a bit easier since all IT staff are based in Nairobi and as such the exercise did not have to be carried out separately for each campus. A total of 26 respondents were targeted as depicted in appendix 6.4

3.3 DATA Collection

The objective of this study is to find out the extent of use of Cloud computing in ACGs and to come up with a framework for migrating services to the Cloud seamlessly. Data such as the following was sought:

- Perception of individuals within the organization towards adoption of the new technology
- Perception towards external factors that influence adoption of the technology
- Level of understanding of Cloud computing technology
- Perception towards Cloud technology
- Perceived advantages of Cloud technology
- Concerns towards adopting Cloud technology

Primary data was collected using a questionnaire available in appendix 6.3 which consisted of both open-ended and closed-ended questions. The questionnaire was sent out to the twenty six respondents using an online survey tool called survey monkey. Additional information was obtained by email correspondence, face to face interviews and telephone calls to the IT manager and other key personnel within the ICT team.

All managers, unit heads and staff who work under them were targeted because the decision to adopt cloud technology is driven by the entire team. Much as implementation is handled by the infrastructure team, the customer service team interfaces with the end users and the application team is in charge of developing new applications and determining where they should be hosted. Cloud technology is implemented at different levels and therefore everyone has a say in determining what is best for the organization. However, due to the fact that this is a relatively new technology in the Kenyan market, the ICT team and units that work closely can be used to represent the entire organization since all service requests come through the ICT team.

Secondary data was collected from the following sources:

- ✓ Interview with the ICT manager
- ✓ Interview with the Infrastructure head
- ✓ Reviewed existing policies on data handling

- ✓ Reviewed data center set up and management
- ✓ Reviewed the existing infrastructure set up and recent investments
- ✓ Reviewed organizations future plans

3.4 Chapter Summary

In this chapter, we looked at the different research designs and selected one that suits our method of research which is a case study. The data collection methods are then explained. The next chapter looks at results, analysis and discussion.

4.0 RESULTS, ANALYSIS AND DISCUSSION

In collecting data for this case study, both primary and secondary sources of data were used. This section will focus on the data findings, analysis and discussion. The data was analyzed using means, standard deviation and then various comparisons were made. Analysis of the data was done using SPSS statistical software. Presentation of the data was made by use of tables. The figures were then interpreted from statistical analysis into descriptive statements. The influence of each determinant factor affecting the adoption decision is discussed. The factors limiting the use of Cloud technology and the main drivers that influence adoption are also discussed.

4.1 Primary Data Findings

An inquiry based questionnaire (as shown on Appendix 6.3) was used to collect primary data.

4.1.1 Demographic information

Response Rate

From a total of twenty six targeted respondents, twenty three interviews were successfully administered within the specified period giving a response rate of 88.46 percent. Out of the twenty three questionnaires received, three were incomplete and therefore a total of twenty were usable for analysis. The total of usable questionnaires was 76.92 percent and this was considered adequate for the purposes of this case study. There was no response from three target respondents.

Distribution within the Organizations

The respondents were selected from both ILRI and ICRAF. Out of the twenty complete questionnaires (see appendix 6.5), 55% were from ILRI, 35% from ICRAF and 10% were jointly appointed by ILRI and ICRAF.

Majority of the respondents were male (90%). The average number of years worked at the institution is 4.35 years. Most of the respondents have at least a bachelor’s degree (95%)

4.1.2 **Effect of Individual Factors**

To evaluate the degree of influence of individual factors in the adoption decision, the respondents were asked a set of questions. Their responses were measured using a 5-point Likert-type interval scale (Strongly disagree – 1 point, Slightly disagree – 2 points, Neutral – 3 points, Slightly agree – 4 points, Strongly agree – 5 points). The results are summarized in the table below:

	Descriptive Statistics - Individual Factors								
		N	Minimum	Maximum	Mean	Std. Deviation	Statistic	LCI	UCI
SEF01	I could administer applications hosted on Cloud platform if there was no one around to tell me what to do as I go	19	1.00	5.00	3.3158	1.33552	0.13777	1.98	3.45
SEF02	I could administer applications hosted on Cloud platform if I had only the software manuals for reference	20	1.00	5.00	3.9000	1.11921	0.10968	2.78	4.01
SEF03	I could administer applications hosted on Cloud platform if I had seen someone else using it before trying it myself	20	1.00	5.00	3.3000	1.52523	0.15734	1.77	3.46
SEF04	I could administer applications hosted on Cloud platform if I could call someone for help if I got stuck	20	1.00	5.00	3.9500	1.39454	0.13666	2.56	4.09
SEF05	I could administer applications hosted on Cloud platform if I had used applications hosted on a similar platform before this one to do the same job	20	1.00	5.00	4.1500	1.42441	0.13959	2.73	4.29
ATT01	I believe that adopting Cloud technology by my firm is a wise decision	20	3.00	5.00	4.4500	0.75915	0.074397	4.3756	4.5244
ATT02	I believe that adopting Cloud technology is helpful to my firm's business	20	3.00	5.00	4.5000	0.68825	0.067448	4.4326	4.5674
ATT03	I believe that Cloud applications are effective tools in my firm	20	3.00	5.00	4.5000	0.76089	0.074567	4.4254	4.5746
SUB01	People who are important to me think that I should use Cloud applications	20	3.00	5.00	4.3500	0.87509	0.085759	4.2642	4.4358
SUB02	People who influence my behavior think that I should use Cloud applications	20	2.00	5.00	4.0000	1.12390	0.110142	3.8899	4.1101
NOTE: SEF = SELF EFFICACY, ATT=ATTITUDE, SUB = SUBJECTIVE NORM									

Table 3 – Individual determinant Factors

Key

Statistic Test statistic for the location of the mean

LCI Lower Confidence Interval

UCI Upper Confidence Interval

The confidence interval calculated with the assumption of a random variable

We conclude with 95% confidence that the mean is located btw the two intervals and cannot be lower than LCI and higher than the UCI

The respective mean averages for the different categories under individual factors were then computed. The group mean for individual factors was then computed and ranking done.

SEF MEAN = (SEF01+SEF02+SEF03+SEF04+SEF05)/5 = 3.72316

ATT MEAN = (ATT01+ATT02+ATT03)/3 = 4.4833

SUB MEAN = (SUB01+SUB02)/2 = 4.175

GROUP MEAN FOR INDIVIDUAL FACTORS = (SEF MEAN +ATT MEAN + SUB MEAN) /3 = 4.127

Ranking for Individual Factors

1	**Attitude**	**4.4833**
2	**Subjective Norm**	**4.175000**
3	**Self-Efficacy**	**3.723160**

Table 4 – Ranking for Individual determinant factors

4.1.3 Effect of Organizational Factors

To evaluate the degree of influence of organizational factors in the adoption decision, the respondents were asked a set of questions. Their responses were measured using a 5-point Likert-type interval scale (Strongly disagree – 1 point, Slightly disagree – 2 points, Neutral – 3 points, Slightly agree – 4 points, Strongly agree – 5 points). The results are summarized in the table below:

	Descriptive Statistics - Organizational Factors								
		N	Minimum	Maximum	Mean	Std. Deviation	Statistic	LCI	UCI
FIN01	My firm has the financial resources to adopt Cloud computing	19	3.00	5.00	4.5789	0.69248	0.071435	4.5075	4.6504
FIN02	My firm has financial resources to implement and maintain Cloud computing	20	2.00	5.00	4.5000	0.88852	0.087075	4.4129	4.5871
EXP01	My firm has technical staff to maintain Cloud applications	20	1.00	5.00	4.3000	1.17429	0.11508	4.1849	4.4151
EXP02	My firm is able to find consultants who are skillful in Cloud applications	20	2.00	5.00	4.5500	0.88704	0.08693	4.4631	4.6369
	Valid N (listwise)	19							
NOTE: FIN = FINANCIAL RESOURCES, EXP = TECHNOLOGICAL EXPERTISE									

Table 5 – Organizational determinant factors

Key

Statistic Test statistic for the location of the mean

LCI Lower Confidence Interval

UCI Upper Confidence Interval

The confidence interval calculated with the assumption of a random variable

We conclude with 95% confidence that the mean is located btw the two intervals and cannot be lower than LCI and higher than the UCI

The respective mean averages for the different categories under individual factors were then computed. The group mean for organizational factors was then computed and ranking done.

FIN MEAN = (FIN01+FIN02)/2 = 4.53945

EXP MEAN = (EXP01+EXP02)/2 = 4.425

GROUP MEAN FOR ORGANIZATIONAL FACTORS = (FIN MEAN + EXP MEAN)/2 = 4.4822

Ranking for Organizational Factors

1	**Financial Resources**	**4.53945**
2	**Technological Expertise**	**4.425**

Table 6 – Ranking for Organizational factors

4.1.4 Effect of Technological Factors

To evaluate the degree of influence of technological factors in the adoption decision, the respondents were asked a set of questions. Their responses were measured using a 5-point Likert-type interval scale (Strongly disagree – 1 point, Slightly disagree – 2 points, Neutral – 3 points, Slightly agree – 4 points, Strongly agree – 5 points). The results are summarized in the table below:

	Descriptive Statistics - Technological Factors								
		N	Minimum	Maximum	Mean	Std. Deviation	**Statistic**	**LCI**	**UCI**
PAD01	Using Cloud application enables my firm to gain and maintain competitive advantage.	20	1.00	5.00	4.1000	1.07115	0.104973	3.9950	4.2050
PAD02	Using Cloud application enables my firm to analyze customer requirements more efficiently.	20	1.00	5.00	3.8000	1.19649	0.117256	3.6827	3.9173
PAD03	Using Cloud application enables my firm to increase customer satisfaction.	20	1.00	5.00	4.0000	1.25656	0.123143	3.8769	4.1231
PAD04	Using Cloud application enables my firm to increase customer loyalty.	20	1.00	5.00	3.4500	1.23438	0.120969	3.3290	3.5710
PAD05	Using Cloud application enables my firm to increase customer retention rate.	20	1.00	5.00	3.5000	1.27733	0.125179	3.3748	3.6252
PAD06	Using Cloud application enables my firm to increase revenue and profitability	20	1.00	5.00	3.7500	1.29269	0.126684	3.6233	3.8767
PAD07	Using Cloud application enables my firm to increase employee productivity	20	1.00	5.00	4.0000	1.25656	0.123143	3.8769	4.1231
PAD08	Using Cloud application enables my firm to reduce overall cost.	20	1.00	5.00	4.2500	1.06992	0.104853	4.1451	4.3549
PES01	I believe that Cloud technology is easy to use.	20	2.00	5.00	4.1000	1.02084	0.100042	4.0000	4.2000
PES02	Learning to use services in the Cloud is easy for me.	20	2.00	5.00	4.3000	0.80131	0.078529	4.2215	4.3785
PES03	I believe that it is easy to use an application hosted in the Cloud the way I would normally use it when hosted in a traditional on-premise environment	20	2.00	5.00	3.7500	1.01955	0.099915	3.6501	3.8499
TRI01	Before deciding whether to adopt Cloud application, I am able to properly try it out	20	2.00	5.00	4.1000	0.96791	0.094855	4.0051	4.1949
TRI02	I am permitted to use Cloud computing on a trial basis long enough to see what it can do.	20	2.00	5.00	4.1000	0.91191	0.089367	4.0106	4.1894
OBS01	I have noticed that Cloud technology is being used by other firms.	20	3.00	5.00	4.5000	0.68825	0.067448	4.4326	4.5674
OBS02	I am aware of the existence of Cloud computing technology in the market	20	4.00	5.00	4.7500	0.44426	0.043538	4.7065	4.7935
OBS03	I know which firms offer Cloud services.	20	3.00	5.00	4.7000	0.57124	0.055982	4.6440	4.7560
COM01	Using Cloud technology is compatible with most aspects of the firm's work.	19	1.00	5.00	4.1053	1.10024	0.113498	3.9918	4.2188
COM02	Using Cloud technology fits with the firm's work style	20	2.00	5.00	4.2000	1.05631	0.103518	4.0965	4.3035
COM03	I think that using Cloud computing fits well with the way I like to work.	20	2.00	5.00	4.4500	0.82558	0.080907	4.3691	4.5309
NOTE: PAD = PERCEIVED ADVANTAGE, PES = PERCEIVED EASINESS, TRI = TRIALABILITY, OBS = OBSERVABILITY, COM = COMPATIBILITY									

Table 7 – Technological determinant factors

Key

Statistic Test statistic for the location of the mean

LCI Lower Confidence Interval

UCI Upper Confidence Interval

The confidence interval calculated with the assumption of a random variable

We conclude with 95% confidence that the mean is located btw the two intervals and cannot be lower than LCI and higher than the UCI

The respective mean averages for the different categories under individual factors were then computed. The group mean for technological factors was then computed and ranking done.

PAD MEAN = (PAD01+PAD02+PAD03+PAD04+PAD05+PAD06+PAD07+PAD08)/8 = 3.85625
PES MEAN = (PES01+PES02+PES03)/3 = 4.05
TRI MEAN = (TRI01+TRI02)/2 = 4.1
OBS MEAN = (OBS01+OBS02+OBS03)/3 = 4.65
COM MEAN = (COM01+COM02+COM03)/3 = 4.251767

GROUP MEAN FOR TECHNOLOGICAL FACTORS = (PAD MEAN + PES MEAN + TRI MEAN + OBS MEAN + COM MEAN)/5 = 4.181603
Ranking for Technological Factors

1	**Observability**	**4.65**
2	**Compatibility**	**4.251767**
3	**Trialability**	**4.1**
4	**Perceived Easiness**	**4.05**
5	**Perceived Advantage**	**3.85625**

Table 8 – Ranking for Technological factors

4.1.5 Effect of Environmental Factors

To evaluate the degree of influence of environmental factors in the adoption decision, the respondents were asked a set of questions. Their responses were measured using a 5-point Likert-type interval scale (Strongly disagree – 1 point, Slightly disagree – 2 points, Neutral – 3 points, Slightly agree – 4 points, Strongly agree – 5 points). The results are summarized in the table below:

	Descriptive Statistics - Environmental Factors								
		N	Minimum	Maximum	Mean	Std. Deviation	Statistic	LCI	UCI
COM01	Competition is a factor in my decision to adopt Cloud technology	20	1.00	5.00	3.4500	1.35627	0.132915	3.5829	3.5829
COM02	I know that my competing rivals already use Cloud technology	20	1.00	5.00	3.6000	1.18766	0.11639	3.7164	3.7164
CUS01	Customers' requirements indicate that a firm needs to have implemented Cloud computing technology.	20	1.00	5.00	2.8000	1.43637	0.140764	2.9408	2.9408
CUS01	Customers' behaviors indicate that a firm needs to have implemented Cloud computing technology	20	1.00	5.00	3.1000	1.61897	0.158659	3.2587	3.2587
IND01	The overall operational practices in my industry pressure me to adopt Cloud computing.	20	2.00	5.00	4.0000	0.91766	0.089931	4.0899	4.0899
IND02	It is a strategic necessity to use Cloud computing technology to compete in my industry.	20	1.00	5.00	3.8000	1.23969	0.12149	3.9215	3.9215
SUP01	The availability of support from technology vendors is a factor in my decision to adopt Cloud computing.	19	1.00	5.00	3.5789	1.50243	0.154988	3.7339	3.7339
SUP02	I know there are technology vendors, who provide technical advice and support for Cloud computing	20	1.00	5.00	4.3000	1.03110	0.101047	4.4010	4.4010
GOV01	I know that the government has policies and initiatives encouraging companies to adopt Cloud computing technology	20	1.00	5.00	2.8500	1.30888	0.12827	2.9783	2.9783
GOV02	I am aware of the existence of governmental agencies providing services toward Cloud computing adoption	19	1.00	5.00	2.5789	1.38707	0.143088	2.7220	2.7220
	Valid N (listwise)	18							
NOTE : COM = COMPETITIVE PRESSURE, CUS = CUSTOMER PRESSURE, IND = INDUSTRY PRESSURE, SUP = EXTERNAL SUPPORT, GOV = GOVERNMENT ENCOURAGEMENT									

Table 9 – Environmental determinant factors

Key

Statistic Test statistic for the location of the mean

LCI Lower Confidence Interval

UCI Upper Confidence Interval

The confidence interval calculated with the assumption of a random variable

We conclude with 95% confidence that the mean is located btw the two intervals and cannot be lower than LCI and higher than the UCI

The respective mean averages for the different categories under individual factors were then computed. The group mean for individual factors was then computed and ranking done.

COM MEAN = (COM01+COM02)/2 = 3.525

CUS MEAN = (CUS01+CUS02)/2 = 2.95

IND MEAN = (IND01+IND02)/2 = 3.9

SUP MEAN = (SUP01+SUP02)/2 = 3.93945

GOV MEAN = (GOV01+GOV02)/2 = 2.71445

GROUP MEAN FOR ENVIRONMENTAL FACTORS = (COM MEAN + CUS MEAN + IND MEAN + SUP MEAN + GOV MEAN)/5 = 3.40578

Ranking for Environmental Factors

1	**External support**	**3.93945**
2	**Industry Pressure**	**3.90000**
3	**Competitive Pressure**	**3.52500**
4	**Customer Pressure**	**2.95000**
5	**Government Encouragement**	**2.71445**

Table 10 – Ranking for environmental factors

Overall Ranking

3	**Attitude**	**4.48330**
6	**Subjective Norm**	**4.17500**
12	**Self-Efficacy**	**3.72316**
2	**Financial Resources**	**4.53945**
4	**Technological Expertise**	**4.42500**
1	**Observability**	**4.65000**
5	**Compatibility**	**4.25177**
7	**Trialability**	**4.10000**
8	**Perceived Easiness**	**4.05000**
11	**Perceived Advantage**	**3.85625**
9	**External support**	**3.93945**
10	**Industry Pressure**	**3.90000**
13	**Competitive Pressure**	**3.52500**
14	**Customer Pressure**	**2.95000**
15	**Government Encouragement**	**2.71445**

Table 11 – Overall ranking for determinant factors

4.1.6 Cloud Technology Adoption Drivers

To evaluate which factors play a major role in the adoption decision, the respondents were asked a set of questions. Their responses were measured using a 5-point Likert-type interval scale (Strongly disagree – 1 point, Slightly disagree – 2 points, Neutral – 3 points, Slightly agree – 4 points, Strongly agree – 5 points). The results are summarized in the table below:

Descriptive Statistics - Cloud Technology Drivers									
	N	Minimum	Maximum	Mean	Std. Deviation	Statistic	LCI	UCI	Ranking
To remove economic/expertise barriers impeding to modernize business processes by the introduction of Information Technology	20	3.00	5.00	4.1000	0.78807	0.077231	4.0228	4.1772	8
Avoiding capital expenditure in hardware, software, IT support	19	3.00	5.00	4.3684	0.76089	0.078491	4.2899	4.4469	5
Enhancing security by outsourcing infrastructure/platforms/services	20	2.00	5.00	3.6500	1.18210	0.115846	3.5342	3.7658	11
Flexibility and scalability of IT resources	19	2.00	5.00	4.4211	0.90159	0.093006	4.3280	4.5141	4
Increasing computing capacity and business performance	20	3.00	5.00	4.4500	0.68633	0.067261	4.3827	4.5173	3
Diversification of IT systems	20	3.00	5.00	4.0000	0.85840	0.084123	3.9159	4.0841	9
Local and global optimization of IT infrastructure through automated management of virtual machines	20	3.00	5.00	4.3000	0.80131	0.078529	4.2215	4.3785	6
Business Continuity and Disaster recovery capabilities	20	4.00	5.00	4.7500	0.44426	0.043538	4.7065	4.7935	1
Assessing the feasibility and profitability of new services (i.e. by developing business cases into the Cloud)	20	1.00	5.00	4.2000	1.05631	0.103518	4.0965	4.3035	7
Adding redundancy to increase availability and resilience	19	2.00	5.00	4.6316	0.76089	0.078491	4.5531	4.7101	2
Controlling marginal profit and marginal costs	20	2.00	5.00	3.7000	1.08094	0.105932	3.5941	3.8059	10
Valid N (listwise)	18								

Table 12 – Cloud technology drivers

Statistic - Test statistic for the location of the mean

LCI Lower Confidence Interval

UCI Upper Confidence Interval

The confidence interval calculated with the assumption of a random variable

We conclude with 95% confidence that the mean is located btw the two intervals and cannot be lower than LCI and higher than the UCI

4.1.7 Cloud Adoption Concerns

To identify the main challenges that ACGs are likely to face when considering migrating applications to the Cloud, the respondents were asked a set of questions. Their responses were measured using a 5-point Likert-type interval scale (Strongly disagree – 1 point, Slightly disagree – 2 points, Neutral – 3 points, Slightly agree – 4 points, Strongly agree – 5 points). The results are summarized in the table below:

Descriptive Statistics - Technology Adoption Concerns									
	N	Minimum	Maximum	Mean	Std. Deviation	Statistic	LCI	UCI	Ranking
Security	20	4.00	5.00	4.9000	0.30779	0.030164	4.8698	4.9302	2
Availability of services and/or data	20	2.00	5.00	4.6500	0.74516	0.073026	4.5770	4.7230	4
Integrity of services and/or data	20	3.00	5.00	4.6500	0.67082	0.06574	4.5843	4.7157	4
Confidentiality of corporate data	20	4.00	5.00	4.9500	0.22361	0.021913	4.9281	4.9719	1
Privacy	20	4.00	5.00	4.8500	0.36635	0.035902	4.8141	4.8859	3
Repudiation	20	3.00	5.00	4.4000	0.82078	0.080437	4.3196	4.4804	6
Loss of control of services and / or data	20	1.00	5.00	4.4000	1.04630	0.102537	4.2975	4.5025	6
Lack of knowledge in the subject area	20	1.00	5.00	3.1500	1.53125	0.150063	2.9999	3.3001	13
Losing current investments	20	1.00	5.00	3.2500	1.37171	0.134427	3.1156	3.3844	11
Lack of liability of providers in case of security incidents	20	1.00	5.00	3.6500	1.42441	0.139592	3.5104	3.7896	8
Unclear government regulations	20	1.00	5.00	2.7500	1.40955	0.138136	2.6119	2.8881	16
Unclear industry regulations	20	1.00	5.00	2.7500	1.40955	0.138136	2.6119	2.8881	16
Unclear scheme in the pay per use approach	20	1.00	5.00	3.1000	1.37267	0.134521	2.9655	3.2345	14
Difficulty of migration to the cloud (legacy software, etc)	20	1.00	5.00	3.1000	1.44732	0.141837	2.9582	3.2418	14
No guaranteed SLA and QoS by Cloud providers	20	1.00	5.00	3.2000	1.32188	0.129544	3.0705	3.3295	12
Cost of migrating services to the Cloud	20	1.00	5.00	3.5500	1.35627	0.132915	3.4171	3.6829	9
Intra-clouds (vendor lock-in) migration	20	1.00	5.00	3.5000	1.23544	0.121073	3.3789	3.6211	10
Valid N (listwise)	20								

Table 13 – Technology Adoption challenges

Statistic - Test statistic for the location of the mean

LCI Lower Confidence Interval

UCI Upper Confidence Interval

The confidence interval calculated with the assumption of a random variable

We conclude with 95% confidence that the mean is located btw the two intervals and cannot be lower than LCI and higher than the UCI

4.2 Secondary Data Findings on Current Computing and Cloud Implementation

Secondary data was collected from the following sources: open ended questions, face to face interviews with the head of ICT and the ICT departmental heads, ICT policy documents, internal and external auditors' reports and ICT unit work plans.

4.2.1 Network Set up

Both ILRI and ICRAF have invested in the same type of network infrastructure. This includes a Cisco 3845 gateway router, Cisco ASA 5520 firewall, HP 5412 core switch and HP Power over Ethernet (PoE) 2910 and 2520 Gigabit access switches. All campus segments are interlinked with high speed fiber backbone links and there is a provision for Ethernet backup for each link.

All devices are managed from a central point using Terminal Access Controller Access Control System (TACACS). Each staff member in the infrastructure team has an account that allows him / her to login and perform rights as per the level of access configured in the system.

The institution has invested in the commercial WhatsUpGold monitoring software and also uses CACTI for network monitoring. Alerts are sent via email to key personnel in the ICT unit in case of an outage.

The institutions have a combined internet bandwidth of 65MB duplex on fiber optic connectivity from three different leading internet service providers in Kenya namely Jamii Telecom, Safaricom and KENET. The two institutions are interlinked using two high speed point to point fiber links from Jamii Telecom and Kenya Data Networks with capacities of 60MB and 100 MB respectively. Connectivity to the internet is configured using border Gateway protocol (BGP) that provides for automatic failover of traffic in case one internet link goes down. Interconnectivity between the two institutions is handled by Open Shortest First (OSPF) protocol that also provides for automatic failover on the point to point links.

4.2.2 Server Set up

The institutions have invested heavily in state of the art servers. The servers are a mix of Dell and HP brands which are regarded very highly in the Kenyan market. ILRI has a total of twenty five physical servers occupying four out of nine racks in the server room while ICRAF has twenty two servers on four racks out of six. The institutions have signed a quarterly maintenance contract for the servers with an external vendor.

The two institutions recently contacted external vendors and implemented server virtualization using VMware and the existing NetApp storage. This has helped cut on the number of physical servers required and space in the server room. Implementation is still ongoing.

4.2.3 Storage

Both institutions have invested in NetApp storage. The storage is used for keeping shared organization data for the different departments, individual data backups for desktops and laptops and archiving for less frequently used data. The storage disks are a mix of high speed fiber channel and Serial Advanced Technology Attachment (SATA) disks. The Common Internet File System (CIFS) is the standard way that computer users in the two institutions share files across corporate intranets and the Internet.

4.2.4 Server Room set up and access

Both institutions have invested heavily in server rooms where servers and network equipment are stored. ILRI has a total of nine 42U racks while ICRAF has six 42U racks. Both institutions have invested in inverter system power back up for server room equipment only with capacity of 30KvA. This is in addition to the institution generators and Kenya Power and Lighting mains supply. ILRI have two high capacity air conditioners that provide cooling in the server room while ICRAF have invested in three mid-range air conditioners to provide cooling in the server room. Access to the server room is controlled by biometric access at ICRAF while ILRI have employed the use of shared code for authorized personnel but they are in the process of rolling out an access control system.

4.2.5 Commonly used Applications

Some of the applications in use apart from EMAIL that runs on a hosted Exchange server and internet include a human resource application (HR4U) that is shared between the two

institutions, online procurement system, intranet and databases running MY SQL.

The institutions made a decision to decommission Exchange servers migrate EMAIL to the head office in USA. The service is currently managed by the internet service provider – CGNET with a guarantee of 24X7X365 support. Plans are underway to also host a finance, grants, and project management software called One corporate system (OCS) in the Cloud. This system will be used by all the sixteen CGIAR centers worldwide.

4.2.6 Access to Applications

At the moment all users have Windows machines running Windows XP or Windows 7 operating system. A few users have Macintosh and Linux. All users are authenticated using Active directory which is hosted on servers running Windows 2008 server operating system. Users who want to work from remote locations have to use Cisco VPN client that guarantees data security using IPSEC (IP Security). All passwords must be changed within 90 days as part of the policy. There is a clear segregation of duties for ICT personnel to ensure that everyone is accountable.

4.3 Discussion

Based on the research findings that have been presented in sections 4.1 and 4.2 of this chapter, there are several observations that can be made. The following discussion is based on the initial objectives of the study as follows: In section 4.3.1, the discussion summarizes the influence of determinant factors within the individual context; section 4.3.2 summarizes the influence of determinant factors within the organizational context; Section 4.3.3 summarizes the influence of determinant factors within the technological context; Section 4.3.4 summarizes the influence of determinant factors within the environmental context; Section 4.3.5 discusses the main factors that drive the adoption of Cloud technology and finally in section 4.3.6 we summarize the main concerns and challenges that ACGs are likely to face when considering migrating applications to the Cloud and 4.3.7 looks at the proposed Cloud computing adoption framework and 4.3.8 outlines the steps that the ACGs can use to adopt Cloud technology using the proposed Cloud computing adoption framework.

4.3.1 Determinant Factors within the Individual Context

The individual context contains three determinant factors: Attitude, Subjective Norm, and Self-efficacy.

Attitude has been found to be an important factor in a number of previous studies. For instance, Harrison D. et al. (1997) find Attitude significantly affects executive decisions on the adoption of IT in small firms. The results of the present study are also in line with these previous studies.

Attitude ranks highest among the individual factors and third overall. This implies that Attitude plays a very significant role when it comes to the decision to adopt or not to adopt Cloud technology. This factor should therefore be given priority when it comes to making the adoption decision.

Venkatesh and Davis (2000) assert that Subjective Norm significantly influences the user's acceptance of technology. Subjective Norm in this study ranks second among individual factors and sixth overall. This factor should therefore be given serious attention when making the adoption decision because most people strongly agree that it is important.

Self-efficacy has the least impact among the individual factors and is ranked twelfth overall. When making the adoption decision, this should be given medium priority.

4.3.2 Determinant Factors within the Organizational context

The organizational context contains two determinant factors: Financial resources and technological expertise.

A firm that has financial resources is better prepared to adopt new technology. This factor is ranked first within the organizational context and second overall. It therefore means that financial resources should be given high priority when making the decision to adopt Cloud technology.

Availability of technological expertise inside the organization has a direct influence on the decision to adopt new technology. Technical expertise ranks second within the organizational context and fourth overall. It therefore means that special attention needs to be given to technological expertise within the firm when making the adoption decision.

4.3.3 Determinant Factors within the Technological Context

The technological context includes six determinant factors: Perceived Advantage, Perceived Easiness, Compatibility, Observability, and Trialability. The influence of each factor is discussed below:

Observability in this study is defined as the degree to which Cloud technology is visible to IT staff. This factor ranks first in the technological context and also first overall. This means that observability should be given high priority when making the adoption decision.

Compatibility ranks second among the technological factors and fifth overall. When making the adoption decision, organizations should ensure that the new technology is compatible with existing applications in order to get full support from IT personnel.

Trialability ranks third among technological factors and seventh overall. This means that when considering adoption of cloud technology, the organization should focus on getting trial software and creating a test environment in order to allow for full testing and piloting before the final decision is made.

Perceived easiness is ranked fourth among the technological factors and eighth overall. When

making the adoption decision, this factor should be given priority.

Perceived advantage is ranked last among the technological factors but eleventh overall. This therefore means that it is still an important factor when making the technology adoption decision.

4.3.4 Determinant Factors within the Environmental Context

The environmental context contains two determinant factors Competitive Pressure, Customer Pressure, Industry Pressure, Governmental Encouragement, and External Support.

External support ranks first within the environmental context and ninth overall. If there is support for a new product from external vendors, firms will be more than willing to adopt new technology. There when considering adoption of Cloud technology, external support should be given attention.

Industry pressure ranks second among environmental factors and tenth overall. This factor has influence when making the adoption decision and should therefore be given attention.

Competitive pressure ranks third within the environmental context and thirteenth overall. Though not highly rated, it should still be given attention.

Customer pressure is ranked fourth within the environmental context and second last overall. With a mean score of 2.9, it means that IT staff within the organization are almost unsure of whether customer pressure can really influence the adoption decision.

Government encouragement is ranked last within the organizational context and also overall among the determinant factors influencing the adoption of cloud computing by ACGs. When making the migration decision, this factor should be given low priority.

4.3.5 Cloud Technology Drivers

From the eleven factors that were analyzed, we can safely say that the most attractive factor when ACGs are making the decision to adopt Cloud technology is Business Continuity and Disaster recovery capabilities, followed by data security, Increasing computing capacity and business performance, Flexibility and scalability of IT resources, Avoiding capital expenditure in hardware, software, IT support, in that order. Enhancing security by outsourcing infrastructure/platforms/services and Controlling marginal profit and marginal costs are the lowest ranked factors.

4.3.6 Cloud Adoption Concerns

From the fourteen challenges that were analyzed, the main concerns that ACGs are likely to face when adopting Cloud technology are confidentiality of corporate data, data security, privacy, integrity and availability of data. The least concerns are Difficulty of migration to the cloud (legacy software, etc.), Unclear scheme in the pay per use approach, Unclear industry regulations and Unclear government regulations

4.3.7 The Proposed Cloud computing Adoption Framework

Having looked at the determinant factors and ranking them, we can then classify them into three categories based on the mean score for individual factors in comparison to our 5-point Likert-type interval scale. Category one will be factors that should be given the highest priority when making the migration decision. These are factors with a mean score of 4.01 and above. This will include: Observability, Financial Resources, Attitude, Technological Expertise, Compatibility, Subjective Norm, Trialability and Perceived Easiness. Category two will have medium priority and this will include factors with a score of 3.01 to 4.0: External support, Industry Pressure, Perceived Advantage, Self-Efficacy and Competitive Pressure.

Category three will be low priority and it will comprise of factors with a mean score of 3.0 and below and this includes: Customer Pressure and Government Encouragement.

Our Cloud computing framework will have three layers of implementation i.e. high priority, medium priority and low priority for each of the four determinant factors.

The Proposed Cloud Computing Adoption Framework

INDIVIDUAL FACTORS		*TECHNOLOGICAL FACTORS*
Low Priority		**Low Priority**
Medium Priority 1. Self-Efficacy	CLOUD TECHNOLOGY ADOPTION	**Medium Priority** 1. Perceived Advantage
High Priority 1. Attitude 2. Subjective Norm		High Priority 1. Observability 2. Compatibility 3. Trialability 4. Perceived Easiness
High Priority 1. Financial Resources 2. Technological Expertise		**High Priority**
Medium Priority		**Medium Priority** 1. External Support 2. Industry Pressure 3. Competitive Pressure
Low Priority		**Low Priority** 1. Customer Pressure 2. Government Encouragement
ORGANIZATIONAL FACTORS		*ENVIRONMENTAL FACTORS*

Figure 19 – The proposed Cloud computing adoption framework

4.3.8 Cloud Adoption Steps

For the two organizations to adopt Cloud technology successfully, they will have to follow the steps outlined in the proposed framework i.e. consider high priority factors within each of the four contexts, then medium priority and finally the low priority factors. The steps outlined in section 2.4 of this thesis give a detailed guide of the adoption process.

STEP 1 – High Priority Factors

Individual and organizational high priority factors will have to be considered first. This is because, individual and organizational factors are considered internal and can thus be controlled by the organization. This will include financial resources and technological expertise. The organizations will have to make provision for the initial cost of migrating applications to the Cloud in the budget. This may be high for a starter but the long term cost benefits for subsequent years will ensure that the funds are recouped. Staff members will have to be trained on technologies like virtualization. By migrating applications to the Cloud, the organization will not have to worry about upgrading servers and storage because this will now be the responsibility of the Cloud vendor. The only cost will be to send ICT personnel for training on changing technologies and operating systems. End users might also require training on how to access applications remotely when they are hosted on the Cloud but this should not be such a significant change to the end user.

The next category of high priority factors is the technological factors. This includes Observability, Compatibility, Trialability and perceived Easiness. The organization will have to take time and check what other organizations have implemented and how the process was handled. This will be a good guide so that they make an informed decision. ILRI and ICRAF have invested in state of the art ICT infrastructure. It will be important to consider this when choosing a technology and provider to implement Cloud technology so that the investment is not declared obsolete. By doing a phased implementation, the institutions can cut costs by riding on the existing infrastructure for a few more years as they migrate to more current infrastructure. At this point, a test environment needs to be set up so that ICT personnel can get a feel of the new

technology and piloting can also be done. This is the phase where challenges like compatibility with legacy applications can be picked out.

When looking at compatibility with existing systems, tests should be done to ensure that migration to Cloud will maintain certain critical elements like secure data access, differentiated levels of access to the system, no policies are violated and data in the Cloud is backed up and can be readily restored.

Cloud technology drivers and adoption challenges and concerns should be considered at every stage of the adoption process.

STEP 2 – Medium Priority Factors

The main medium priority internal factor to be considered will be Self-Efficacy. It will be important to find out the level of experience in working with Cloud technology from ICT staff and then gauge where to start the tests or adoption process from. If the technical members of staff feel confident about the technology, then the adoption process can start at a higher level.

The external factors will include perceived advantage, external support, industry pressure and competitive pressure. It is important for the two institutions to look at the advantages that adopting the technology will give them in the research sector. Before a decision to migrate applications to the Cloud is made, it will also be important for the institutions to confirm that there are certified vendors in the region and that there is adequate support for the product that they choose. Background checks can be done on the vendors to ensure that they are financially stable and they have the right personnel and infrastructure in place to support the product.

STEP 3 – Low Priority Factors

Even though not very important, it is important to also look at the low priority factors. This includes customer pressure and government encouragement. In looking at customer pressure, it is important to understand the changing needs of the end user and fulfill their requirements. In this case the institutions will have to ensure that all members of staff are able to work comfortably and the Cloud model picked can satisfy the needs of staff members.

4.4 Chapter Summary

This chapter looked at the results, analysis and discussion of the results. This included: Demographic information, factors influencing the adoption decision i.e. individual, organizational, technological and environmental. The main factors driving the adoption of Cloud technology were analyzed and finally the main challenges ACGs are likely to face when adopting Cloud technology were evaluated. The final product of this chapter is the proposed Cloud computing adoption framework and the steps to be followed by ACGs during the adoption process are explained in the final section. In the next chapter, we shall draw conclusions of the study and give recommendations for future study.

5.0 CONCLUSION

5.1 The Objectives

In this study, the four widely used adoption models, the Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), Social Cognitive Theory (SCT), and Diffusion of Innovation (DOI) were combined into one model that captures individual, organizational, technological and environmental factors that influence the adoption of Cloud technology. We also looked at the main factors that drive the decision to adopt Cloud technology and the challenges ACGs are likely to face when making a decision to adopt Cloud technology.

All in all, this study has answered the research question and fulfilled all the research objectives.

a) **Objective 1 – To identify existing on-premise computing and Cloud computing technologies and building a case for ACGs to migrate applications to the Cloud**

In our literature review, we looked at the current computing trends from a technical and business perspective and compared with the new Cloud computing technology. Different Cloud service models and Cloud deployment models were reviewed and the advantages and disadvantages of each model outlined. We looked at the benefits and limitations of Cloud computing and also outlined which category of users should use Cloud computing and who should not. Section 4.2 of this thesis is an analysis of secondary data to gain an in-depth understanding of the existing on premise IT computing and Cloud implementation at the two institutions that are being studied. The secondary data gives a detailed explanation of the network set up, server implementation, data storage configuration, server room set up and access controls, existing applications and application access and controls that have been put in place to manage day to day operations of the ICT department.

When the two institutions decide to migrate to the Cloud, they will be able to cut down on cost of power and power back up, reduce on the number of server racks and thus reduce the space required for the server room and cooling. It is important to note that the institutions charge for office space and this will be a significant saving for the ICT

department.

The two institutions have already migrated EMAIL application to the Cloud and tests are being done on the One Corporate System application. This means that some level of Cloud computing has already been implemented and staff already have experience of using applications hosted in the Cloud. This should make accessing the rest of the applications easy when they will eventually be moved to the Cloud.

b) Objective 2 – to identify Cloud technology drivers

Section 4.1.6 of this thesis gives an evaluation of factors that play a major role in the adoption decision. The information is summarized in table 12. Section 4.3.5 gives a summary of the Cloud technology drivers and the ranking from highest to lowest. We can therefore conclude that the most attractive factors when ACGs are making the decision to adopt Cloud technology are Business Continuity and Disaster recovery capabilities. As the institutions make a decision to adopt Cloud technology, these are the main factors that should be put into consideration. Increasing computing capacity and business performance and improving flexibility and scalability of IT resources are also some of the driving factors. The rest of the seven factors are also important since they all get a score above 3.7 out of the maximum 5.0

c) Objective 3 – To identify the determinant factors influencing the adoption of Cloud computing by ACGs

In section 2.4.9 of this thesis, we combined several models to come up with our conceptual model. In the conceptual model, we identified the four main determinant factors: Individual, Organizational, Technological and environmental. The main determinant factors under each category are:

Individual context: Attitude, Subjective Norm, Self-efficacy, Innovativeness, Technological expertise

Technological context: Perceived Advantage, Perceived Easiness, Compatibility, Observability and Trialability

Organizational context: Financial Resources and Technological Expertise

Environmental context: Competitive Pressure, Customer Pressure, Industry Pressure, Government Encouragement, External support from technology vendors.

d) Objective 4 – To identify the degree of influence of each determinant factor in the adoption of Cloud computing technology by ACGs

From our primary data findings derived from the administered questionnaire, Section 4.1.2 looks at the effect of individual factors and a summary is captured in table 3. Section 4.1.3 looks at the effect of Organizational factors and a summary is captured in table 5. Section 4.1.4 looks at the effects of Technological factors and the summary is captured in table 7. Finally, section 4.1.5 looks at the effect of environmental factors and a summary is captured in table 9. Mean scores are computed for each of the individual determinant factors and captured in tables 4, 6, 8 and 10. Table 11 combines all the scores for the individual determinant factors and gives a clear ranking that captures Observability as the factor with the highest mark followed by financial resources of the organization and Government encouragement being the factor with the lowest score. It should however be noted that the lowest score of 2.71445 out of the maximum 5.0 is still above the 50% mark meaning that all the individual factors have a great influence on the adoption decision. In sections 4.3.1, 4.3.2, 4.3.3 and 4.3.4 we also discuss the determinant factors within the Individual, Organizations, Technological and Environmental Context respectively.

e) Objective 5 - To identify the main concerns and challenges that ACGs are likely to face when considering migrating applications to the Cloud

The main challenges that the two institutions are likely to face are summarized in section 4.1.7 and a detailed discussion in section 4.3.6. A total of 17 aspects were evaluated using a questionnaire and the main concern was confidentiality of corporate data followed by data security and privacy of data. Of least concern were unclear industry regulations and unclear government regulations. The lowest score was 2.75 out of a maximum 5.0 meaning that all concerns have a great bearing on the adoption decision.

f) Objective 6 – To formulate the Cloud computing framework for adoption of Cloud technology

The proposed Cloud computing framework was our main objective of this research. The proposed Cloud adoption framework has been captured in section 4.3.7 of this thesis and it outlines the four main factors i.e. Individual, Organizational, Technological and

Environmental. Each of the individual determinant factors under each category is classified as either High priority, Medium priority or Low priority. The classification is based on the individual mean scores as captured in table 11. All individual factors with a score of 4.01 and above (i.e. Strongly agree on the 5-point Likert-type interval scale) will be considered High priority. Individual factors with a mean score of 3.01 to 4.0 will be in the Medium category and 3.0 and below will be considered Low priority.

g) **Objective 7 – To evaluate the proposed framework**

Evaluation of the proposed framework will be an ongoing process as the organizations decide to migrate applications to the Cloud. Key personnel within the institutions led by the ICT manager will be invited to look at the proposed framework and give suggestions.

The findings can guide ACGs to encourage adoption of Cloud technology since there seems to be some reluctance due to fear of challenges and the other factors that we have analyzed. By using the Cloud proposed computing framework, adopting Cloud technology will be an easy process since all the determinant factors have already been categorized and the main focus should be on the high priority areas in each of the four quadrants.

5.2 Limitations of the Study

Number of Organizations and Respondents

There are very many agricultural research institutions in Kenya but in this case study, only twenty respondents from the two ACGs were interviewed. Therefore, the conclusions made in the study cannot be considered to be representative the situation in Kenya and also in the Agricultural research sector as well. Expanding the research to other institutions might give different results.

The mode of data collection

The interview and questionnaire method of data collection inherently, as statistical techniques, result in the respondents giving subjective opinions on their assessment of risk. There are more scientific and objective risk assessment data collection tools and methods, but these were not used due to time constraints.

Constraints in Available resources

There were also limitations in the available financial resources, time available, literature that was accessible and the number of respondents that could be interviewed. These all contributed towards restricting the data collection technique that was used and the study design.

Lack of References from Local Cases

During the entire duration of conducting this case study, there were no known Kenyan case studies on adoption of Cloud technology amongst agricultural research institutions.

5.3 Limitations and suggestions for further research

The findings of this research are limited to adoption of Cloud technology by ACGs. It is possible that the findings might be different for other sectors. Expanding this research to cover all agricultural institutions in Kenya might also give different results.

The focus of this study is only on adoption. Implementation of Cloud technology and selection of a Cloud computing model are not covered. Further research looking at the effect of determinant factors in each implementation phase is suggested.

REFERENCES

Ajzen, I. (1985) From intentions to actions: A theory of planned behavior, Berlin, Springer.

Ajzen, I. (1991) The theory of planned behavior, "Organizational Behavior and Human Decision Processes", Vol. 50, pp 179-211.

Ashok Dhiman (2010) Analysis of On-Premise to Cloud computing migration strategies for enterprises

Carayannis, E. G., & Turner, E. (2006). Innovation diffusion and technology acceptance: The case of PKI technology. Technovation, 26(7), 847-855.

Chetan Kothari, A.K. (July 12, 2010). Cloud Application Migration. Cloud Computing journal.

Cisco Cloud Computing - Data Center Strategy, Architecture, and Solutions Point of View White Paper for U.S. Public Sector 1st Edition (2009)

Cloud Computing: Concept, Model, and Key Technologies - Kevin Yin (2010) - http://wwwen.zte.com.cn/endata/magazine/ztecommunications/2010Year/no4/articles/201012/t20101220_196759.html/ - accessed on 3rd November 2012

Davis, F.D. (1986) A technology acceptance model for empirically testing new end-user information systems: Theory and results, Sloan School of Management, Massachusetts Institute of Technology.

Davis, F.D. (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology, "MIS Quarterly", Vol. 13, No. 3, pp 319-340.

Douglas Parkhill (1966), *The Challenge of the Computer Utility*

Dreyfuss, C.(Feb 2010). Cloud-computing Service Trends : Business Value Opportunities and Management Challenges. Gartner.

Golden, B. (2010, April 1). IT Operations: Beware the Cloud Boomerang. Retrieved from

Network World: http://www.networkworld.com/news/2010/040110-it-operations-beware-the-cloud.html

Harrison, A. W., Rainer, R. K. Jr., & Hochwarter, W. A. (1997). Gender differences in computing activities. Journal of Social Behavior & Personality, 12(4), 849-868.

ILRI/ICRAF shared ICT portal - http://ict.worldagroforestry-ilri.org/policies

James Staten, T.S. (2009) Q&A: By 2011, CIOs Must Answer The Question, "Why Not Run In The Cloud. Forrester Research,5.

Jeon, B. N., Han, K. S., & Lee, M. J. (2006). Determining factors for the adoption of e-business: The case of SMEs in Korea. Applied Economics, 38(16), 1905-1916.

Joshua Shivo (2010) – Business Continuity Planning – A case of Agricultural Research Institutions in Kenya

Kuan, K. K. Y., & Chau, P. Y. K. (2001). A perception-based model for EDI adoption in small businesses using a technology-organization-environment framework. Information & Management, 38(8), 507-521

McNamara, Carter, *Basic Business Research Methods*, Field Guide to Nonprofit Program Design, Marketing and Evaluation, 4th Edition, 2000

McNamara, Carter, Basic Business Research Methods, Field Guide to Nonprofit Program Design, Marketing and Evaluation, 4th Edition, 2000

Mell, P., and T. Grance. 2009. "The NIST Definition of Cloud Computing." Version 15, 10-7-09. CSRC, http://www.nist.gov/itl/cloud/upload/cloud-def-v15.pdf, accessed September 2011.

NIST Cloud Computing Reference Architecture - Recommendations of the National Institute of Standards and Technology -Fang Liu, Jin Tong, Jian Mao, Robert Bohn, John Messina,

Lee Badger and Dawn Leaf – September 2011

NIST Special Publication 800-144 Guidelines on Security and Privacy in Public Cloud Computing Wayne Jansen, Timothy Grance - December 2011
Vivek Kundra (2011) – Federal Cloud Computing Strategy

NIST - US Government Cloud Computing Technology Roadmap Volume II Release 1.0 (Draft) - Lee Badger, Robert Bohn, Shilong Chu, Mike Hogan,Fang Liu, Viktor Kaufmann, Jian Mao, John Messina,Kevin Mills, Annie Sokol, Jin Tong, Fred Whiteside and Dawn Leaf - November 2011

Porcari, E. M. 2009. "Ubiquitous Networks and Cloud Computing."Thinkpiece for CGIAR Science Forum Workshop on ICTsTransforming Agricultural Science, Research, and Technology Generation," Wageningen, Netherlands. 16–17 June 2009.

Rogers, E. M. (1983). Diffusion of innovation (3rd ed.). New York: the Free Press.

Rogers, E.M. (1995) Diffusion of innovations, Fourth Edition ed., New York, Free Press.

Rogers, E. M. (2003). Diffusion of innovation (5th ed.). New York: the Free Press.

Tarun Juneja (2011) cloud computing limitation blog. https://meghainfotech.wordpress.com/2011/04/21/limitations-of-cloud-computing/ - posted on April 21 2012 and accessed on 4th August 2012

Thong, J. Y. L. (1999). An integrated model of information systems adoption in small businesses. Journal of Management Information Systems, 15(4), 187-214.

Tornatzky, L. and Fleischer, M. (1990) The process of technology innovation, Lexington, MA, Lexington Books.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies.

Wayne Jansen and Timothy Grance (2011) - Guidelines on Security and Privacy in Public Cloud Computing

6.0 APPENDIX

6.1 Agricultural Research Institutions based in Kenya

Consultative Group on International Agricultural Research (CGIAR) Centers	International Centre for Research in Livestock (ILRI)
	World Agroforestry Center (ICRAF)
Non-Governmental Organizations (NGOs)	ActionAid Kenya
	African Conservation Centre
	African Wildlife Foundation
	Amboseli Cultural Bomas Association
	Amboseli Elephant Research Project
	Amboseli/Tsavo Game Scouts Association
	Amboseli/Tsavo Group Ranches Association
	Centre for Wildlife Studies
	Eselenkei Community Conservation Area
	Friends of Nairobi National Park
	Institute of Policy Analysis and Research
	Intermediate Technology Development Group
	Kajiado Wildlife Forum
	Kitengela Landowners Association
	Kitengela Women's Group
	Kitirua Community Concession Area
	Mara Conservancy
	Mara Wildlife Associations/Trusts
	Strengthening Informal Sector Training and Enterprises
	Swedish VI Programme in Lake Victoria
	The four Amboseli group ranches (Imbirikani, Kimana, Olgulului/Lolarrashi, and Eselenkei)
	The Group Ranches in Narok
Advanced Research Institutes (ARIs)	International Centre of Insect Physiology and Ecology
	Mpala Research Centre
Regional and Eco-regional Organizations	African Agriculture Technology Foundation
	African Centre for Technology Studies
	African Union Inter-African Bureau for Animal Resources
	ASARECA Animal Agriculture Research Network
International Organizations	United Nations Environment Programme

	United Nations Environment Programme's Division of Global Environment Facility Coordination
National Agricultural Research Systems (NARS)	Amboseli National Park
	Arid Lands Program/Office of the President
	Central Bureau of Statistics
	Department of Remote Sensing and Surveys
	Department of Veterinary Services, Kenya
	Department of Veterinary Services-Kenya Veterinary Association
	Egerton University
	Greenbelt Movement Kenya
	Institute of Molecular and Cell Biology, Africa
	Jomo Kenyatta University of Agriculture and Technology
	Kajiado District Officer's office
	Kenya Agricultural Research Institute
	Kenya Agricultural Research Institute – Trypanotolerance Research Centre
	Kenya Dairy Board
	Kenya Institute for Public Policy Research and Analysis
	Kenya Medical Research Institute
	Kenya Veterinary Vaccine Production Institute
	Kenya Wildlife Service
	Kenyatta University
	Ministry of Agriculture, Kenya
	Ministry of Environment and Natural Resources - Department of Resource Surveys and Remote Sensing, Kenya
	Ministry of Environment and Natural Resources, Kenya
	Ministry of Health, Kenya
	Ministry of Livestock and Fisheries Development, Kenya
	Ministry of Planning and National Development, Kenya
	Narok County Council
	National Environment Management Authority
	Olkejuado County Council
	Tegemeo Institute of Agricultural Policy and Development, Egerton University
	University of Nairobi

Excerpt from http://www.ilri.org

6.2 Regional Offices of ILRI and ICRAF

ICRAF	ILRI
1. Peru – Lima, Pucallapa 2. Brazil – Belem 3. Indonesia – NAD, Muara Bungo, Bogor 4. Philippines – Lantapan, Visayas, Claveria, Los Banos 5. Thailand – Chiang Mai 6. Vietnam – Vietnam 7. China – Kunming, Beijing 8. India – New Delhi 9. Sri Lanka – Colombo 10. Senegal – Dakar 11. Mali – Bamanko, Segoue 12. Guinea – Conakry, Labe 13. Cameroon – Yaounde 14. DR Congo – Kinshasa 15. Rwanda – Kigali 16. Kenya – Meru, Kisumu 17. Tanzania – Dar es Salaam 18. Mozambique – Maputo 19. Zambia – Chipata 20. Zimbabwe – Harare 21. Malawi – Lilongwe 22. Bangladesh – Dhaka 23. Bhutan – Bhutan 24. Nepal – Nepal	1. Ethiopia – Addis Ababa 2. Nigeria – Ibadan 3. Niger – Niamey 4. Mozambique – Maputo 5. Colombia – Cali 6. Nicaragua – Managua 7. China – Beijing 8. Vietnam – Hanoi 9. India – New Delhi, Andhra Pradesh

6.3 Research Questionnaire

Email Communication to Respondents

Dear Colleague,
I would like to invite you to kindly participate in this survey: "A Framework for Cloud Computing Migration for Agricultural Research Institutions in Kenya". This survey forms part of my MSc study requirements and all the information that you provide will be used for purposes of this research only. The questionnaire will take you only a few minutes to complete.

Kindly complete the survey by end of business Thursday, 31st January 2013.

Here is a link to the survey:
https://www.surveymonkey.com/s/DKWKBQK

Thank you for your participation.

Regards,
James Mukabi Indimuli

QUESTIONNAIRE

Survey Questionnaire on
A Framework for Cloud computing migration for Agricultural Research Institutions in Kenya

Instructions:

The objective of this questionnaire is to collect the information in relation to designing a framework for Cloud computing migration for Agricultural Research Institutions in Kenya. Your answer is important to the accuracy and preciseness of this research. Your personal information shall be kept strictly confidential and the data will be exclusively used for this research only. The questionnaire comprises eleven sections. Please read the questions in each section carefully and complete the questionnaire according to the given instructions.

Definition

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

It is a technology that uses the internet and central remote servers to maintain data and applications. Cloud computing allows consumers and businesses to use applications without installation and access their personal files at any computer with internet access. This technology allows for much more efficient computing by centralizing storage, memory, processing and bandwidth.

Cloud computing is a general term for anything that involves delivering hosted services over the Internet. These services are broadly divided into three categories: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS).

There are three relevant types of cloud models: Private (internal or vendor-hosted), Public (external), and Hybrid (mixed)

Section I: Demographic Information

Name of the organization: _____

Name of Respondent: _____

Sex: ❑1 Male ❑2 Female

Your age: _____years

Designation of Respondent: _____

Department / Theme / Project: _____

Section / Unit: _____

Duration worked for Institute: _____ year(s)_____ month(s)

Duration worked in IT industry : _____year(s)_____month(s)

Your education level :

❑1 High school ❑2 Vocational/ Diploma ❑3 Bachelor
❑4 Master ❑5 Doctorate ❑6 Other

Section II: Cloud Management

1.Does your company host any applications in the Cloud?

❑1 Yes ❑2 No (SKIP TO SECTION II)

2.Which layer of Cloud applications is currently being used by your company?
(MORE THAN ONE ANSWER MAY BE CHOSEN)

- ☐ Individual software packages – Software as a Service (SaaS)
- ☐ Complete operating system and software package available via Cloud services (PaaS)
- ☐ Just infrastructure services such as storage, network capacity, etc – Infrastructure as a Service (IaaS)

☐ Other (Please specify)……

3. Based on the answer to question (2) above, how was the migration of the application(s) to the Cloud handled? (CHOOSE ONLY ONE ANSWER)

❑1 The application(s) was migrated to Cloud environment by our internal technical resources

❑2 The application(s) migration was managed by our internal technical team with help from a consultant

❑3 An outsider (consultant / outsourced company) was engaged to migrate the application(s)

☐ Other (Please specify)……

4. Which solution do you see as the most suitable for your organization according to this possible Cloud computing taxonomy?

☐ Public cloud (owned and managed by an unrelated business)

☐ Private Cloud (owned and managed internally)

☐ Hybrid cloud (some services hosted internally and some hosted in the public cloud)

☐ Other (Please specify)……

Section III: Characteristics of Respondent

Please indicate to what extent you agree with the listed statements by using the following scale

Strongly Disagree (1)	Slightly Disagree (2)	Neutral (3)	Slightly Agree (4)	Strongly Agree (5)

I could administer applications hosted on Cloud platform
…..if there was no one around to tell me what to do as I go.

…..if I had only the software manuals for reference.

…..if I had seen someone else using it before trying it myself.

…..if I could call someone for help if I got stuck.

…..if I had used applications hosted on a similar platform

before this one to do the same job.

Section IV: Perception towards Cloud Technology Adoption

Please indicate to what extent you agree with the listed statements by using the following scale

Strongly Disagree (1)	Slightly Disagree (2)	Neutral (3)	Slightly Agree (4)	Strongly Agree (5)

I believe that adopting Cloud technology by my firm is a wise decision.

I believe that Cloud applications are effective tools in my firm

People who are important to me think that I should use Cloud applications.
People who influence my behavior think that I should use Cloud applications.

My firm has the financial resources to adopt Cloud computing.
My firm has financial resources to implement and maintain

Cloud computing.

My firm has technical staff to maintain Cloud applications.
My firm is able to find consultants who are skillful in Cloud applications.

Section V : Perception Towards Cloud Technology

Please indicate to what extent you agree with the listed statements by using the following scale

Strongly Disagree (1)	Slightly Disagree (2)	Neutral (3)	Slightly Agree (4)	Strongly Agree (5)

Using Cloud technology is compatible with most aspects of the firm's work.
Using Cloud technology fits with the firm's work style
I think that using Cloud computing fits well with the way I like to work.

I believe that Cloud technology is easy to use.
Learning to use services in the Cloud is easy for me.
I believe that it is easy to use an application hosted in the Cloud the way I would normally use it when hosted in a traditional on-premise environment
Before deciding whether to adopt Cloud application, I am able to properly try it out.

I am permitted to use Cloud computing on a trial basis long enough to see what it can do.

I have noticed that Cloud technology is being used by other firms.
I am aware of the existence of Cloud computing technology in the market.
I know which firms offer Cloud services.

Section VI : Cloud Technology Drivers

Please indicate to what extent you agree with the listed statements by using the following scale

Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree
1	2	3	4	5

The main reasons behind possible engagement in the Cloud Computing area are?

Avoiding capital expenditure in hardware, software, IT support, Information
Enhancing security by outsourcing infrastructure/platforms/services
Flexibility and scalability of IT resources
Increasing computing capacity and business performance
Diversification of IT systems
Local and global optimization of IT infrastructure through automated management of virtual machines
Business Continuity and Disaster recovery capabilities
Adding redundancy to increase availability and resilience

Other (please specify)…….

Section VII: Perception towards External Factors

Please indicate to what extent you agree with the listed statements by using the following scale

Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree
(1)	(2)	(3)	(4)	(5)

Competition is a factor in my decision to adopt Cloud technology.
I know that my competing rivals already use Cloud technology.

Customers' requirements indicate that a firm needs to have implemented Cloud computing technology.

Customers' behaviors indicate that a firm needs to have implemented Cloud computing technology
The overall operational practices in my industry pressure me to adopt Cloud computing.
It is a strategic necessity to use Cloud computing technology to compete in my industry.

The availability of support from technology vendors is a factor in my decision to adopt Cloud computing.
I know there are technology vendors, who provide technical advice and support for Cloud computing.

I know that the government has policies and initiatives encouraging companies to adopt Cloud computing technology.
I am aware of the existence of governmental agencies providing services toward Cloud computing adoption.

Section VIII :Application Hosting Preference

Please indicate to what extent you agree with the listed statements by using the following scale

Strongly Disagree (1)	Slightly Disagree (2)	Neutral (3)	Slightly Agree (4)	Strongly Agree (5)

The following IT services /applications supporting business processes are most likely to be outsourced to a Cloud computing service provider by my organization:

Payroll
Human Resources
Procurement
Accounting and finance
Project management
Application development in the cloud
Web hosting
Email
IP Telephony management
Storage
Laboratory Information Management System
Other (please specify)……..

Section IX: Cloud Concerns

Please indicate to what extent you agree with the listed statements by using the following scale

Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree
1	2	3	4	5

My organization's main concerns when approaching Cloud computing are?

Data Security

Availability of services and/or data

Integrity of services and/or data

Confidentiality of corporate data

Privacy

Loss of control of services and / or data

Lack of knowledge in the subject area

Losing current investments

Lack of liability of providers in case of security incidents

Unclear government regulations

Unclear industry regulations

Unclear scheme in the pay per use approach

Difficulty of migration to the Cloud (legacy software, etc)

No guaranteed SLA and QoS by Cloud providers

Cost of migrating services to the Cloud

Intra-clouds (vendor lock-in) migration

Other (please specify)……..

THANK YOU FOR YOUR COOPERATION!!

6.4 List of Target Respondents

	NAME	Email Address	Designation	Department	Status
1	Ian Moore	i.moore@cgiar.org	ICT Manager	ICT	Complete
2	Rosemary Kande	r.kande@cgiar.org	ICT Customer Service Manager	ICT	Incomplete
3	George Ogoti	g.ogoti@cgiar.org	ICT Server Specialist	ICT	Complete
4	Harrison Gatumu	h.gatumu@cgiar.org	ICT Network Specialist	ICT	No response
5	Robert Okal	r.okal@cgiar.org	ICT Infrastructure Specialist	ICT	Incomplete
6	Sam Asura	s.asura@cgiar.org	ICT Database Specialist	ICT	Complete
7	David Sunwa	d.sunwa@cgiar.org	ICT Helpdesk Admin - ILRI	ICT	Complete
8	Caroline Nzui	c.nzui@cgiar.org	ICT Helpdesk Admin - ICRAF	ICT	No response
9	Wallace Ngene	wtngene@cgiar.org	ICT Customer Support Technician	ICT	Complete
10	Phillip Oyuko	p.oyuko@cgiar.org	ICT Customer Services Officer	ICT	Complete
11	Carolyne Mwangi	c.mwangi@cgiar.org	ICT Customer Services Officer	ICT	Complete
12	Grace Miceka	g.miceka@cgiar.org	ICT Customer Services Officer	ICT	Complete
13	Hilary Wanyiri	h.wanyiri@cgiar.org	ICT Customer Services Specialist	ICT	Complete
14	Benjamin Kimuri	b.Kimuri@cgiar.org	ICT Customer support Technician	ICT	Complete
15	Isaac Kihara	i.kihara@cgiar.org	ICT Business Systems Coordinator	Finance	Complete
16	Alan Orth	aorth@cgiar.org	Research Associate	Bioinformatics Group	Complete
17	Absolomon Kihara	a.kihara@cgiar.org	ICT Business Systems Coordinator	Bioinformatics Group	Complete
18	Isaac Kahugu	i.kahugu@cgiar.org	Linux specialist	Bioinformatics Group	Complete
19	Leroy Mwanzia	l.mwanzia@cgiar.org	Data Systems Specialist	RMG	Complete
20	Linus Kabutha	l.kabutha@cgiar.org	MIS Manager	Finance	No response
21	Edwin Kipchumba	e.kipchumba@cgiar.org	MIS Officer	Finance	Complete
22	Solomon Mwangi	k.smwangi@cgiar.org	Web Co-ordinator	Communications	Complete
23	Titus Karanja	tkaranja@cgiar.org	Data Archivist	RMG ILRI	Complete

24	Nicholas Mwenda	nmwenda@cgiar.org	ICT Customer services	ICT	Complete
25	Emmanuel Nzavi	e.nzavi@cgiar.org	ICT Customer Services	ICT	Incomplete
26	Barack Wanjawa	b.wanjawa@cgiar.org	ICT Liaison	Engineering	Complete

6.5 List of Respondents who completed the Questionnaire

NUMBER	**Company**	**NAME**	**GENDER**	**AGE**	**TITLE**	**DEPARTMENT**	**YEARS WORKED**	**Education Level**
R01	ICRAF	Edwin Kipchumba	Male	31 - 35	MIS OFFICER	FINANCE	4	Bachelor
R02	ILRI	Alan Orth	Male	26 - 30	Systems Analyst	Research Methods Group	3	Bachelor
R03	ILRI / ICRAF	Ian Moore	Male	Over 45	Head ICT	ICT	14	Bachelor
R04	ICRAF	Carolyne Mwangi	Female	26 - 30	ICT Customer Service Officer	Corporate Services	5Years	Bachelor
R05	ILRI	Benjamin Kimuri	Male	26 - 30	ICT Customer Services Technician	Corporate Services	3 Years	Bachelor
R06	ILRI	Hilary Wanyiri	Male	31 - 35	ICT CS Specialist	Corporate Services	5	Bachelor
R07	ILRI	Isaac Kahugu	Male	26 - 30	Linux Systems Administrator	Research Methods Group	1	Bachelor
R08	ICRAF	Wallace Ngene Taruru	Male	31 - 35	ICT Customer Services Officer	ICT	3	Vocational/ Diploma
R09	ILRI	Titus Karanja	Male	26 - 30	Data Archivist	RMG	4	Master
R10	ICRAF	Phillip Isaac Oyuko	Male	26 - 30	ICT Customer Services Officer	ICT	2 Years 5 Months	Bachelor
R11	ILRI	Isaac Kihara	Male	31 - 35	Business Systems Coordinator	ICT	3 weeks	Bachelor

R12	ILRI	Grace	Female	31 - 35	ICT Customer Services Officer	ICT	1 Year 2 Months	Bachelor
R13	ILRI	David Sunwa	Male	26 - 30	ICT ADMIN	Corporate	2	Bachelor
R14	ILRI	Wanjawa, W. B.	Male	41 - 45	Maintenance Coordinator	Engineering	6	Bachelor
R15	ICRAF	solomon	Male	26 - 30	webmaster		4	Master
R16	ILRI	Kihara Absolomon	Male	26 - 30	Data Manager	BioTechnology /AVID	3.5	Bachelor
R17	ICRAF	Nicholas	Male	26 - 30	ICT Technician	ICT	2 Years	Bachelor
R18	ICRAF	Leroy Mwanzia	Male	31 - 35	Data Systems Specialist	Research	2	Bachelor
R19	ILRI / ICRAF	GEORGE OGOTI	Male	36 - 40	ICT ACTING INFRASTRACTURE MANAGER	ICT	11	Bachelor
R20	ILRI	Sam Asura	Male	41 - 45	ICT Database Specialist	ICT	11	Bachelor

6.6 Summary of Data Collected

Summary of Data Collected (Individual Factors)

	RESPONSES																			
	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
I believe that adopting Cloud technology by my firm is a wise decision	5	3	5	4	4	3	4	5	5	5	5	5	5	4	5	4	5	5	5	3
I believe that Cloud applications are effective tools in my firm	4	3	5	5	3	4	4	5	5	5	5	5	5	4	5	5	5	5	5	3
People who are important to me think that I should use Cloud applications	3	4	5	5	5	4	4	5	3	5	5	5	5	3	3	5	5	5	5	3
People who influence my behavior think that I should use Cloud applications	3	2	5	5	5	4	3	5	3	5	5	3	5	2	5	4	3	5	5	3
I could administer applications hosted on Cloud platform if there was no one around to tell me what to do as I go	3	4	5	3	1	4	3	1	4	5	3	3	1	4		4	5	2	5	3
I could administer applications hosted on Cloud platform if I had only the software manuals for reference	4	4	5	4	2	5	3	5	3	5	3	4	1	4	5	4	5	4	5	3
I could administer applications hosted on Cloud platform if I had seen someone else using it before trying it myself	2	4	5	5	1	4	3	1	3	4	1	5	1	3	5	2	5	5	4	3
I could administer applications hosted on Cloud platform if I could call someone for help if I got stuck	4	4	5	5	1	5	4	3	4	5	4	5	1	4	5	1	5	5	5	4
I could administer applications hosted on Cloud platform if I had used applications hosted on a similar platform before this one to do the same job	4	4	5	5	5	5	4	5	5	5	1	5	1	4	5	1	5	5	5	4

Summary of Data Collected (Organizational Factors)

	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
My firm has the financial resources to adopt Cloud computing	5	3	3	4	5	5	4	5	5	5	5	5	5	5		5	5	4	5	4
My firm has financial resources to implement and maintain Cloud computing	5	2	3	4	5	5	4	5	5	5	5	5	5	5	5	5	5	4	5	3
My firm has technical staff to maintain Cloud applications	1	2	4	4	5	5	3	5	5	5	5	5	5	5	5	5	5	3	5	4
My firm is able to find consultants who are skillful in Cloud applications	3	2	4	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	3

Summary of Data Collected (Technological Factors)

	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
Using Cloud technology is compatible with most aspects of the firm's work	4	4	4	4	4	5	1	5	5	5	5	3	5	4		4	5	4	5	2
Using Cloud technology fits with the firm's work style	4	2	5	4	5	5	2	5	2	5	5	4	5	4	5	4	5	4	5	4
I think that using Cloud computing fits well with the way I like to work	4	2	5	4	4	4	3	5	4	5	5	4	5	5	5	5	5	5	5	5
I believe that Cloud technology is easy to use	5	2	4	4	4	5	3	5	3	4	5	5	5	4	5	2	5	3	5	4
Learning to use services in the Cloud is easy for me	4	2	4	4	4	5	3	5	4	5	5	5	5	4	5	4	5	4	5	4
I believe that it is easy to use an application hosted in the Cloud the way I would normally use it when hosted in a traditional on-premise environment	4	4	4	4	2	4	3	5	3	2	4	3	5	5	4	5	4	5	2	3
Before deciding whether to adopt Cloud application, I am able to properly try it out	3	4	4	2	5	4	4	5	3	5	5	4	5	5	4	5	4	4	5	2
I am permitted to use Cloud computing technology on a trial basis long enough to see what it can do	3	4	5	4	4	5	4	5	3	4	5	3	4	4	5	5	5	3	5	2
I have noticed that Cloud technology is being used by other firms	4	4	5	3	5	5	4	5	5	5	5	5	4	3	5	4	5	5	5	4
I am aware of the existence of Cloud computing technology in the industry	5	4	5	4	5	5	5	5	5	5	5	5	5	4	5	5	5	4	5	4
I know which firms offer Cloud services	5	4	5	4	5	5	5	5	5	5	5	5	5	3	5	5	5	4	5	4

Summary of Data Collected (Environmental Factors)

	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
Competition is a factor in my decision to adopt Cloud technology	4	1	3	4	4	4	2	5	3	1	5	4	5	3	5	1	5	3	4	3
I know that my competing rivals already use Cloud technology	4	1	5	4	5	2	3	5	3	4	3	3	5	2	5	3	5	3	4	3
Customers' requirements indicate that my firm needs to have implemented Cloud computing technology	3	1	2	3	2	1	1	3	2	5	3	3	5	1	4	1	5	3	5	3
Customers' behaviors indicate that my firm needs to have implemented Cloud computing technology	3	1	5	4	1	1	1	5	4	5	3	3	5	1	5	1	3	3	5	3
The overall operational practices in my industry pressure me to adopt Cloud computing	5	4	3	5	4	2	4	5	4	5	4	4	3	3	5	3	5	4	5	3
It is a strategic necessity to use Cloud computing technology to compete in my industry	5	2	4	4	3	2	4	5	4	5	5	4	3	4	5	1	5	4	5	2
The availability of support from technology vendors is a factor in my decision to adopt Cloud computing	5	2	4	5	1	1	4	5	4	5	4	3		2	5	1	4	5	5	3
I know there are technology vendors, who provide technical advice and support for Cloud computing	5	4	5	5	1	5	4	5	4	5	5	3	4	4	5	5	5	4	5	3
I know that the government has policies and initiatives encouraging companies to adopt Cloud computing technology	2	2	3	4	1	1	3	5	3	1	2	3	5	2	5	3	4	2	4	2
I am aware of the existence of governmental agencies providing services towards Cloud computing adoption	1	2	3	3	1	2	3	5	3	1	2	3	5	1		2	5	1	4	2

Summary of Data Collected (Cloud Technology Drivers)

	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
Avoiding capital expenditure in hardware, software, IT support, Information	5	4	4	3	5	5	4	5	3	5	4	3	5	5		5	4	4	5	5
Enhancing security by outsourcing infrastructure/platforms/services	5	4	4	2	3	3	3	5	3	3	2	5	5	5	2	3	5	2	5	4
Flexibility and scalability of IT resources	5	4	5	5	5	3	4		5	2	5	4	4	5	5	5	5	5	5	3
Increasing computing capacity and business performance	5	3	5	5	4	4	4	5	5	5	5	4	4	4	5	4	5	5	5	3
Diversification of IT systems	5	3	4	5	4	5	3	5	3	5	5	4	5	3	3	3	4	4	4	3
Local and global optimization of IT infrastructure through automated management of virtual machines	5	4	3	4	5	3	4	5	5	5	5	4	4	4	5	3	5	5	5	3
Business Continuity and Disaster recovery capabilities	5	4	4	5	5	5	4	5	5	5	5	5	4	5	5	5	5	5	5	4
Adding redundancy to increase availability and resilience	5	4	5	4	5	5	4	5	2	5	5	5	5	5		5	5	5	5	4

Summary of Data Collected (Cloud Migration challenges)

	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
Data Security	5	4	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5
Availability of services and/or data	5	2	5	2	5	5	2	5	5	5	5	5	5	2	5	5	5	2	5	5
Integrity of services and/or data	5	4	5	4	5	5	4	5	5	5	5	5	5	3	5	5	5	3	5	5
Confidentiality of corporate data	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Privacy	5	4	5	5	5	4	5	5	5	5	5	5	5	5	4	5	5	5	5	5
Loss of control of services and / or data	1	4	5	4	5	3	5	5	3	5	5	5	5	4	5	5	5	4	5	5
Lack of knowledge in the subject area	1	4	3	4	1	2	4	4	1	5	4	5	5	2	5	1	4	1	4	3
Losing current investments	1	4	3	2	5	2	3	4	1	4	4	5	5	3	5	5	3	2	2	2
Lack of liability of providers in case of security incidents	2	3	3	4	5	2	5	1	1	5	2	5	5	4	5	4	4	5	3	5
Unclear government regulations	1	3	3	2	5	1	4	1	1	3	3	4	5	2	2	1	2	5	3	4
Unclear industry regulations	1	3	3	2	5	1	4	1	1	3	3	4	5	2	2	1	2	5	3	4
Unclear scheme in the pay per use approach	2	4	3	3	5	1	3	1	1	5	3	4	5	1	2	4	4	4	3	4
Difficulty of migration to the Cloud (legacy software, etc)	2	4	4	2	2	2	5	1	4	5	2	5	5	3	2	1	1	4	4	4
No guaranteed SLA and QoS by Cloud providers	3	3	5	2	2	4	5	1	3	5	2	4	5	2	2	3	2	2	4	5
Cost of migrating services to the Cloud	2	3	4	2	2	3	5	5	3	5	2	5	5	3	3	1	3	5	5	5
Intra-clouds (vendor lock-in) migration	3	3	4	2	5	3	5	5	3	4	2	5	5	2	3	1	3	3	5	4

NB: The shaded boxes represent open ended answers.