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MSL Framework: (Minimum Service Level Framework) for Cloud Providers and Users

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Abstract

MSL Framework: (Minimum Service Level Framework) for Cloud Providers and Users

(Under the supervision of Professor Luís Borges Gouveia)

Cloud Computing ensures parallel computing and emerged as an efficient technology to meet the challenges of rapid growth of data that we experienced in this Internet age. Cloud computing is an emerging technology that offers subscription based services, and provide different models such as IaaS, PaaS and SaaS among other models to cater the needs of different user groups. The technology has enormous benefits but there are serious concerns and challenges related to lack of uniform standards or nonexistence of minimum benchmark for level of services offered across the industry to provide an effective, uniform and reliable service to the cloud users. As the cloud computing is gaining popularity, organizations and users are having problems to adopt the service ue to lack of minimum service level framework which can act as a benchmark in the selection of the cloud provider and provide quality of service according to the user's expectations. The situation becomes more critical due to distributed nature of the service provider which can be offering service from any part of the world. Due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the industry there are serious concerns raised recently in-terms of security and data privacy breaches, authentication and authorization issues, lack of third party audit and identity management problems, integrity, confidentiality and variable data availability standards, no uniform incident response and monitoring standards, interoperability and lack of portability standards, identity management issues, lack of infrastructure protection services standards and weak governance and compliance standards are major cause of concerns for cloud users. Due to confusion and absence of universal agreed SLAs for a service model, different quality of services is being provided across the cloud industry. Currently there is no uniform performance model agreed by all stakeholders; which can provide performance criteria to measure, evaluate, and benchmark the level of services offered by various cloud providers in the industry. With the implementation of General Data Protection Regulation (GDPR) and demand from cloud users to have Green SLAs that provides better resource allocations mechanism, there will be serious implications for the cloud providers and its consumers due to lack of uniformity in SLAs and variable standards of service offered by various cloud providers.

This research examines weaknesses in service level agreements offered by various cloud providers and impact due to absence of uniform agreed minimum service level framework on the adoption and usage of cloud service. The research is focused around higher education case study and proposes a conceptual model based on uniform minimum service model that acts as benchmark for the industry to ensure quality of service to the cloud users in the higher education institution and remove the barriers to the adoption of cloud technology. The proposed Minimum Service Level (MSL) framework, provides a set of minimum and uniform standards in the key concern areas raised by the participants of HE institution which are essential to the cloud users and provide a minimum quality benchmark that becomes a uniform standard across the industry. The proposed model produces a cloud computing implementation evaluation criteria which is an attempt to reduce the adoption barrier of the cloud technology and set minimum uniform standards followed by all the cloud providers regardless of their hosting location so that their performance can be measured, evaluated and compared across the industry to improve the overall QoS (Quality of Service) received by the cloud users, remove the adoption barriers and concerns of the cloud users and increase the competition across the cloud industry.

Key Words

CIAA (Confidentiality, Integrity, Availability, Authentication), Cloud Computing, Data Security, General Data Protection Regulation (GDPR), Minimum Service Level (MSL) Framework, Service Level Agreement (SLA), Utility Computing.

RESUMO

Sohail Razi Khan: MSL Framework: (Framework de Nível de Serviço Mínimo) para Provedores e Usuários de Nuvem
(Sob a supervisão do Professor Luís Borges Gouveia)

A computação em nuvem proporciona a computação paralela e emergiu como uma tecnologia eficiente para enfrentar os desafios do crescimento rápido de dados que vivemos na era da Internet. A computação em nuvem é uma tecnologia emergente que oferece serviços baseados em assinatura e oferece diferentes modelos como IaaS, PaaS e SaaS, entre outros modelos para atender as necessidades de diferentes grupos de utilizadores. A tecnologia tem enormes benefícios, mas subsistem sérias preocupações e desafios relacionados com a falta de normas uniformes ou inexistência de um referencial mínimo para o nível de serviços oferecidos, na indústria, para proporcionar uma oferta eficaz, uniforme e confiável para os utilizadores da nuvem. Como a computação em nuvem está a ganhar popularidade, tanto organizações como utilizadores estão enfrentando problemas para adotar o serviço devido à falta de enquadramento de nível de serviço mínimo que possa agir como um ponto de referência na seleção de provedor da nuvem e fornecer a qualidade dos serviços de acordo com as expectativas do utilizador. A situação torna-se mais crítica, devido à natureza distribuída do prestador de serviço, que pode ser oriundo de qualquer parte do mundo. Devido à falta de enquadramento de nível de serviço mínimo que irá agir como um *benchmark* para fornecer um serviço uniforme em toda a indústria, existem sérias preocupações levantadas recentemente em termos de violações de segurança e privacidade de dados, autenticação e autorização, falta de questões de auditoria de terceiros e problemas de gestão de identidade, integridade, confidencialidade e disponibilidade de dados, falta de uniformidade de normas, a não resposta a incidentes e o monitoramento de padrões, a interoperabilidade e a falta de padrões de portabilidade, questões relacionadas com a gestão de identidade, falta de padrões de serviços de proteção das infraestruturas e fraca governança e conformidade de padrões constituem outras importantes causas de preocupação para os utilizadores. Devido à confusão e ausência de SLAs acordados de modo universal para um modelo de serviço, diferente qualidade de serviços está a ser fornecida através da nuvem, pela indústria da computação em nuvem. Atualmente, não há desempenho uniforme nem um modelo acordado por todas as partes interessadas; que pode fornecer critérios de desempenho para medir, avaliar e comparar o nível de serviços oferecidos por diversos fornecedores de computação em nuvem na indústria.

Com a implementação do Regulamento Geral de Protecção de Dados (RGPD) e a procura da nuvem com base no impacto ambiental (Green SLAs), são acrescentadas precupações adicionais e existem sérias implicações para os forncedores de computação em nuvem e para os seus consumidores, também devido à falta de uniformidade na multiplicidade de SLAs e padrões de serviço oferecidos. A presente pesquisa examina as fraquezas em acordos de nível de serviço oferecidos por fornecedores de computação em nuvem e estuda o impacto da ausência de um quadro de nível de serviço mínimo acordado sobre a adoção e o uso no contexto da computação em nuvem. A pesquisa está orientada para a adoção destes serviços para o caso do ensino superior e as instituições de ensino superior e propõe um modelo conceptualt com base em um modelo de serviço mínimo uniforme que funciona como referência para a indústria, para garantir a qualidade do serviço para os utilizadores da nuvem numa instituição de ensino superior de forma a eliminar as barreiras para a adoção da tecnologia de computação em nuvem. O nível de serviço mínimo proposto (MSL), fornece um conjunto mínimo de normas uniformes e na áreas das principais preocupações levantadas por responsáveis de instituições de ensino superior e que são essenciais, de modo a fornecer um referencial mínimo de qualidade, que se possa tornar um padrão uniforme em toda a indústria. O modelo proposto é uma tentativa de reduzir a barreira de adoção da tecnologia de computação em nuvem e definir normas mínimas seguidas por todos os fornecedores de computação em nuvem, independentemente do seu local de hospedagem para que os seus desempenhos possam ser medidos, avaliados e comparados em toda a indústria, para melhorar a qualidade de serviço (QoS) recebida pelos utilizadores e remova as barreiras de adoção e as preocupações dos utilizadores, bem como fomentar o aumento da concorrência em toda a indústria da computação em nuvem.

Palavras chave

CIAA (Confidencialidade, Integridade, Disponibilidade, Autenticação), Computação em Nuvem, Segurança de Dados, Regulamento Geral de Proteção de Dados (RGPD), Nível Minimo de Serviço (MSL), Acordo de Nível de Serviço (SLA), Utility Computing.

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DEDICATION

I dedicate this work to my father who always inspired me to achieve this final PHD degree. My mother that was source of advice in the difficult time. This work was not possible without my wife who understood that time required to complete this piece of work. My two young children that waited for me outside my room while I was working on the research.

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LIST OF ABBREVIATIONS

ASP	Application Service Provider
AM	Active Manager
ABE	Attribute-Based Encryption
BPM	Business Process Management
CSA	Cloud Security Alliance
CIAA	Confidentiality, Integrity, Availability, Authenticity
CLR	Common Language Runtime
CEO	Chief Executive Officer
CSS	Cascading Style Sheets
CDN	Content Distribution Network
DAAS	Database as a Service
DAS	Direct Attached Storage
DoS	Denial of Service
EC	Electronic Commerce
ESX	Elastic Sky X
ESB	Extensible Mark-up Language
FPS	Frames per Second
FC	Fibre Channel
GB	Giga Byte
GPS	Global Positioning System
GPU	Graphics Processing Unit
GFS	Google File System
HTML	Hypertext Mark-up Language
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
HE	Higher Education
IaaS	Infrastructure as a service

IP	Internet Protocol
I/O	Input/ Output
IBE	Identity-Based Encryption
IPTV	Internet Protocol Television
ISCSI	Internet Small Computer System Interface
IBS	Identity-Based Signature
LRE	Lazy Re-Encryption
NAS	Network Attached Storage
NASA	National Aeronautics and Space Administration
NIST	National Institute of Standards and Technology
OVF	Open Virtualization Format
MSQL	Microsoft Structured Query Language
PaaS	Platform as a service
PRE	Proxy Re-Encryption
PDA	Personal Digital Assistant
RDBMS	Relational Database Management Systems
RIA	Rich Internet Applications
RSA	Ron Rivest, Adi Shamir, and Leonard Adleman
RSS	Really Simple Syndication
REST	Representational State Transfer
RFID	Radio Frequency Identification Devices
SaaS	Software as a Service
SAS	Serial Attached SCSI
SAN	Storage Area Network
SCSI	Small Computer System Interface
SLA	Service Level Agreement
SQL	Structured Query Language
SOAP	Simple Object Access Protocol
STB	Set Top Box

SSLAP	Secure Sockets Layer Authentication Protocol
TB	Tera Byte
TPM	Trusted Platform Module
VAS	Value Added Service
VMC	Virtual Machine Contract
VOD	Video on Demand
WAN	Wide Area Network
XML	Extensible Mark-up Language

CHAPTER 1. Introduction

1.1 Introduction

The term "Cloud Computing" is defined by the National Institute of Standards and Technology (NIST) as "a model or enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, server, storage, applications, and services) that can be rapidly provisioned and released with minimal effort or service provider interaction" (NIST, 2010). In the last years, the computation has experienced enormous changes from centralized to distributed system and now moving back to the centralization as a structure. According to the (NIST: SP800-145, 2011), the benefits of the cloud computing are many where the model significantly cut IT infrastructure costs and this can be used for operational expenses. The model provides on-demand access to vast IT resources that are available in the cloud technology. The rapid growth of data which we have experienced in this Internet age, the capacity of normal PC cannot meet the demand of large-scale massive data scientific computing according to (Eisa et al, 2016). The model with its benefits have lots of concerns which have been raised. This model leaves the client/customer not aware of where the data is stored or how it is maintained. Due to the design of the model the client or customers has lack of or no control over their data and where Internet is used as a communication media to access data. The security and privacy of the data in the cloud computing is a major issue and the provider has to provide concrete assurance in Service Level Agreement (SLA) to assure the customer regarding the data protection and privacy issues (Radha, Babu, and Rao, 2015). The increase of public cloud providers, cloud consumers face various challenges such as data security and privacy issues, authorization and authentication breaches, poor availability standards, lack of interoperability and response time standards, methodology to allocate resources, weak or no third party audit mechanism and lack of monitoring and responses standards (Alabbadi, 2016). As you see from the figure 1.1: Customers' biggest concern; (KPMG U.K) in 2016 carried out a detailed investigation and identifies major concerns of users while using cloud services. The main findings of the research indicate data loss, privacy, confidentiality, interoperability challenges, lack of clarity in-terms of legal and regulatory compliance issues and lack of standards of services offered by various cloud providers. The findings also highlight the weak governance and compliance standards challenges, lack of infrastructure protection services standards as major cause of concerns for cloud users. Due to confusion and absence of universal agreed SLAs for a service model, different quality of services is being provided across the cloud industry

(Burkon and Lukas, 2013). Currently there is no uniform performance model agreed by all stakeholders; which can provide performance criteria to measure, evaluate, and benchmark the level of services offered by various cloud providers in the industry (Arjun and Vinay, 2016). It is not possible to fulfil all the customers' expectations where service providers are offering different quality of service and there is no framework or a uniform service model to benchmark the services offered by these various cloud providers in the industry.

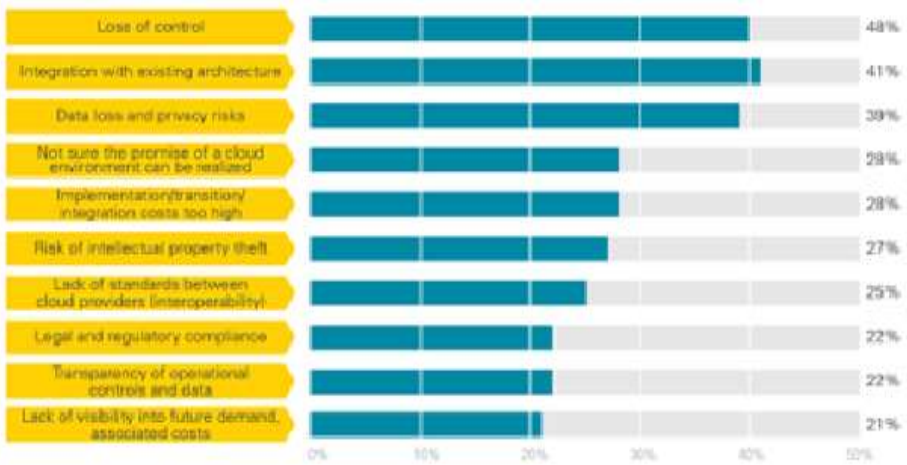


Figure 1.1: Cloud Users Biggest Concerns- KPMG International's

Global Cloud Provider Survey (n-179), (2016)

Cloud computing is an emerging technology and facing a growing demand so hundreds of technology based companies such as Amazon, Salesforce, Google, Microsoft, IBM, Yahoo and many others are trying to capitalize on the emerging market according to the detailed study carried by Accenture consultancy USA in (2010). Based on this study more companies can bring better competition, improve the QoS (Quality of Service), deliver choices, reduce infrastructure cost for businesses, improved productivity and efficiency and meet customer's requirements. With all these benefits there are serious concerns and barriers faced by various companies and users in the adoption of cloud technology due to variable level of services or no uniform standards offered by various cloud providers (Alabbadi, 2016). The author further explains that due to lack of uniform standards agreed by all the cloud industry it is confusing for the cloud users to differentiate and select the cloud provider and considered as a major barrier to the adoption of cloud technology. These concerns are shared by (Hossain

et.al,2012), there is an increasing number of cloud providers but selection of the provider according to their set requirements is a difficult job due to lack of uniform standards or absence of a minimum benchmark that is agreeable to all the providers operating in the cloud industry. The selection of the cloud services is a completely different from any online services. As there is no set framework for selection of cloud providers this leads to variable Quality of Service (QoS) offered by various cloud providers which is major hurdle in the adoption of cloud technology (Eisa et al, 2016).

As cloud services are different in nature such as the case of SaaS (Software-as-a-Service); PaaS (Platform-as-a-Service); and IaaS (Infrastructure-as-a-Service). To select a SaaS service provider different providers such as Salesforce, Google Apps will have different quality of services standards in-terms of security, privacy, integrity, authentication and authorization (Mathew, 2017). Due to lack of uniform framework, the cloud users and providers will have different interpretation and the level of expectation will be different for the cloud services which is major cause of contention and serious challenge in the adoption of the technology (Mircea and Andreescu, 2011). The situation becomes very difficult if there is no standards or benchmark to measure the quality of service of the cloud services providers (Radha, Babu, and Rao, 2015) which leads to lack of accountability on the part of cloud provider and considered as a major barrier to the adoption of cloud technology as the quality of service does not meet the cloud user's expectations.

At the start of selection of the cloud provider, the negotiation process between the potential users and the cloud provider takes place in which they agree on set standards known as Service Level Agreement (SLAs) (Wu, Garg, and Buyya, 2016). SLAs consist of Quality of Services (QoS), these are different rules which are contractual bounded to be followed both the parties. SLA parameters are scalability, privacy, security, availability which increases the level of confidence to the cloud users. The main purpose of SLA is to define the each QoS and identify the responsibility (Zhu, et al, 2016). It enables the end-users to agree on the type of services offered, and those who will be responsible for the service execution. If there is SLA breach, the cloud provider is subject to pay for the SLA breach as the contract shall describe what will be the consequences if the quality of service is not meet (Mathew, 2017). The author further states that due to lack of uniform standards of SLAs offered by the cloud

providers; the providers are not legally obliged to provide any template or a benchmark or pay back for any losses. This is due to lack of standards in the cloud industry. The cloud providers will provide uptime as the main indicators whereas other services are not clear and situation becomes more difficult when identical services is given different price, quality of services and customer experience by different cloud providers according to the author. There is a critical need to have a mechanism to provide minimum service level framework that acts as a quality of services benchmark to the customers who are using or planning to use the cloud computing services regardless of their location, size of the business and business needs. A mechanism or a framework that provides comprehensive set of services that are crucial and helps the selection of the cloud provider and acts as uniform standard that guarantees the quality of set of services to the cloud users and resolve the cloud adoption challenges faced by the potential and existing cloud users.

1.2 Problems and Issues Research: Case Study

The Higher Educational (HE) institution can be the biggest beneficiary of using the cloud computing infrastructure with major savings (Ouf, Nasr and Helmy, 2016). As the HE institutions are trying to reduce cost, improve productivity and efficiency, cloud technology can provide benefits as they don't have to invest heavily on to maintain their computing infrastructure according to the report published by OECD (2012a). But at the same time implementing cloud computing technology in the HE institution consist of various adoption challenges due to lack of or absence of uniform service level framework that can act as a benchmark to set standards for service delivery (Baranwal and Vidyarthi, 2016).

The main aim of this research will be focused around the challenges faced by a HE institution in the adoption of cloud technology. In order to conduct this research, a specific HE institution case study is selected and a detailed investigation will be carried out to examine the issues and challenges faced in the adoption of cloud computing technology. The research will also investigate the problems and barriers due to lack of minimum or uniform service level framework agreed across the cloud industry and its implications on the cloud users in the institution. The research will investigate from the target audience such as students, staff, management and technical support team about the issues and concerns regarding the adoption of cloud technology in the HE institutions.

With increased number of educational institutions opting for cloud services; this raises many questions and the one which needs urgent attention is lack of minimum standards across the providers or what type of minimum service level should students, staff and employees of the educational organizations should expect from the cloud providers. The situation becomes more critical due to distributed nature of the service provider which can be offering service from any part of the world. Here the question should be raised how the students, staff and senior management at HE institutions should be satisfied with the security, privacy and integrity of their data where a provider can be operating across the world with different standards of security requirements and different set of laws and policy. The use of cloud technology for HE institutions raises various issues and challenges in terms of: data security and privacy; authorization and authentication; availability; interoperability and third part audit mechanism; governance and compliance standards and legal and regulatory issues to ensure that cloud providers follows compressive framework to meet the quality of services requirements of the cloud users. Currently the concern that is shared with the potential cloud users in a HE institution is that there is no framework or minimum set of standards agreed by the cloud industry which can help them in the selection of cloud provider and acts as a benchmark to provide consistent and uniform minimum quality of service offered by cloud providers regardless of their hosting location or size of operation. Due to lack of uniform service framework the process of selecting the cloud provider, comparing and evaluating the level of service offered by the cloud provider is considered as major challenges and adoption barrier in HE institutions to the integrate cloud technology.

The research will investigate and highlight various challenges and issues which are faced by the cloud users in the specific HE institution due to lack of uniform framework. The research will carry out a critical analysis on different SLAs provided by various cloud providers and compare them to highlight the differences in terms and condition. The research will propose a uniform framework MSL (Minimum Service Level) Framework, for HE institution that provides minimum service level standards across the industry which will enable cloud users to choose the provider based on reliable and universally agreed mechanism and measure the performance of various providers based on this model. This proposed MSL framework will improve the overall level of service offered by the cloud providers and acts as minimum benchmark for cloud industry. The proposed framework will address the adoption concerns by potential cloud users in the HE institution and also set minimum standards for cloud

providers to make them accountable for the level of service offered. The proposed MSL framework, provides a set of minimum and uniform standards in the key concern areas raised by the participants of a HE institution which are essential to the cloud users and provide a minimum quality benchmark that becomes a uniform standard across the industry. The proposed model is an attempt to reduce the adoption barrier of the cloud technology and set minimum uniform standards followed by all the cloud providers regardless of their hosting location so that their performance can be measured, evaluated and compared across the industry to improve the overall quality of service received by the cloud users, remove the adoption barriers and concerns of the cloud users and increase the competition across the cloud industry.

1.3 Research Question

The Research question to be investigated is as follows:

Q) Is it possible to implement a Minimum Service Level framework for higher educational institution's users (students, staff and employees); offering a uniform standard of service clearly defining a benchmark for all the cloud providers across the industry regardless of their hosting locations.

The main question to be investigated in this research is the implementation of Minimum Service Level (MSL) Framework for HE institution's users (students, staff and employees) so that there is a uniform standard of services across the cloud industry regardless of their hosting location. The above research questions will resolve critical issues faced by students, staff, senior management and technical support team at different HE institutions using cloud services on daily basis. The research will provide a framework to enforce and comply a minimum service level standard that acts like a benchmark to measure the performance of different cloud providers according to the proposed framework. The proposed MSL framework will address and resolve the adoption challenges to the cloud technology in the HE institution, improve the overall quality of service offered by the cloud providers and acts as a set of criteria or standards containing performance indicator according to which the services offered by the providers to improve the overall accountability process across the cloud industry.

1.4 Research Aims and Objectives

There is a critical need to have a **MSLF Minimum Service Level Framework** that clearly defines a universal benchmark for a certain set of standards in terms of quality of services offered by various cloud providers regardless of their hosting location. The universal minimum service level standards will act as a performance indicator which will enable the users at the HE institution to select easily the best cloud provider based according to their requirements, evaluate and measure the cloud provider's performance against other providers, and make them accountable according to the proposed framework. The proposed model might increase the cloud adoption rate, satisfy the existing cloud users and improve the overall competition and quality of service offered by various cloud providers in the industry. The aim and objectives of the research are as follows:

Aim of the Research

- To implement a Minimum Service Level Framework; for HE institution's users (students, staff and employees); offering a uniform standard of service clearly defining a quality benchmark for all the cloud providers across the industry regardless of their locations.

Objectives

- To identify different flaws and weaknesses in the current Service Level agreement offered by the cloud providers.
- To investigate and identify the adoption barriers faced by HE institutions and its users while implementing the cloud computing technology.
- To formulate a list of requirements and preferences in the adoption of cloud technology by the cloud users in the HE institution.
- To propose and design a detailed a Conceptual framework; consist of various layers and phases which will act as a Minimum Service Level framework for the HE institution by resolving the adoption barriers and according to the requirements of cloud users.

The proposed framework consist of best industry practices, guidelines and recommendation for each criteria and offer a universal agreed minimum standards to improve the quality of service offered by all cloud providers regardless of their hosting location or size of operation.

1.5 Research Contributions

As the cloud computing is gaining popularity organizations and users are having problems to adopt the service due to lack of minimum service level framework which can act as a benchmark in the selection of the cloud provider and provide quality of services according to the user's expectations. The research will contribute by investigating the impact of lack of minimum service level framework and what problems the existing and the new cloud users for e.g. students, staff and employees at an HE institution are facing while trying to adopt or use the cloud service. The main contribution of the research is to investigate the SLAs offered by various cloud providers and propose a MSL (Minimum Service Level) Framework for HE institutions offering a universal agreed standards of set services that will act as a benchmark for all the providers across the industry regardless of their hosting location. The framework provides a minimum standard for set of key services which are very crucial to the cloud users and provide better quality of services.

The proposed MSL framework will address and resolve the adoption barrier of cloud technology in the HE institutions and provide a mechanism to the potential new cloud customers to choose and compare the quality of service offered by the cloud provider regardless of their hosting location. The framework will reduce any ambiguity and confusion and allow improve the cloud adoption rate. The framework will acts as a benchmark for minimum expectable standards in-terms of Quality of Service (QoS), and ensure trustworthiness of service provider, remove ambiguity of implementation of law and data protection and uniform performance indicators to choose the provider easily based on set standards regardless of their hosting location. Following are some more contributions to the research:

- To investigate the existing Service Level Agreements offered by cloud providers to HE institutions to identify problems and challenges faced by the cloud users
- Identify the most critical requirements and problems for the existing and new cloud users at HE institutions. Investigate the key threats and challenges faced by all the participants in adoption and use of cloud services.
- To propose a Minimum Service Level Framework; for HE institution's users (students, staff and employees); offering a uniform standards of service clearly

defining a benchmark for all cloud providers across the industry regardless of their locations.

- To propose and recommend guidelines for each criteria in the proposed framework to share best practices in the implementation of MSL framework
- To implement a uniform standard across the cloud industry that will provide framework to the students, staff, senior management and employees of the HE institutions to choose the cloud provider regardless of their hosting location; measure and evaluate their performance and expect minimum uniform recognised standards on all key set of services such as security, privacy and availability of data.

The proposed MSL framework also provide additional functionality that allows:

- To address the adoption challenges and issues with the current users of cloud technology in a HE institution, thus improving the overall QoS (Quality of Services) offered by various cloud providers.
- The research will produce a "Cloud Computing Implementation Evaluation Criteria" that can act as a guideline for cloud providers and potential cloud users.
- The creation of key performance indicators that will assist the HE institution to select the best cloud provider, measure their performance and make them accountable for the quality of service offered according to the framework.

1.6 Structure of the thesis

Here, briefly, it presents the organization and content of the thesis which comprises nine chapters that have been organized to allow the presentation and reporting of the research, namely:

Chapter I - Introduction: presents a general introduction to the work that makes the framework of the study produced. This chapter also presents the thesis study, its context, objectives and relevance. It also introduces the research problem and the resulting key work contributions.

Chapter II- The chapter focuses on how higher education and its social and technological impact on the society. The chapter reflects on key challenges of globalization and how the higher education institutions should adapt and evolve to these ever growing trends. The above

chapters also provides an insight into the UK higher education institution structure and the changes which UK education sector has seen in the last many years. The chapter also emphasises on the need of seeking quality education, integration of technology into higher education and design a knowledge economy but this also requires the improvement of higher education institutions.

Chapter III- The chapter provides a detailed insight into the cloud technology, adoption models their usage by providing an historical background followed by the various service and implementation model details. The chapter also compares cloud technology with similar technologies and explain various commercial products. In the latter part of the chapter the adoption challenges of the chapter are discussed in-detail followed by the impact of cloud computing on various industries.

Chapter IV- In chapter of the study the research explains the cloud usage in different sectors and its application. The chapter also highlight the adoption of cloud computing in higher education and what are their main end user groups for cloud services. The chapter provides detail insight into the cloud architecture and various deployment models used by the HE institutions. The chapter discusses the cloud adoption benefits and challenges faced by HE institutions. The study examines four case studies of various HE institutions across the world and examine the implementation benefits and challenges in these case studies.

Chapter V- As the cloud computing is gaining popularity both organizations and users are having problems to adopt cloud services due to poor and variable QoS standards. The issues can be seen as the major requirement and need to be addressed to improve the adoption rate of cloud computing technology so the researcher proposes Minimum Service Level (MSL) framework model to the cloud industry. This model also addresses the concerns raised during the literature review which were faced in the adoption of cloud technology. The framework provides minimum standards for a set of key services which are crucial to cloud users and can provide better QoS and standards. The framework will remove any ambiguity, confusion and resolve the legitimate concerns of the cloud users which will result in the improvement of adoption of cloud services across the industry.

Chapter VI- The research is based on a specific HE institution case study which will provide a holistic account of the issues related. The specific HE institution have deployed the cloud computing technology and the researcher will investigate the adoption barrier to the use of

technology. To gain a detailed understanding of all the issues around the barriers in the adoption and implementation of cloud technology in the HE institution this can only be achieved using semi-structured interviews and qualitative questionnaires due to time constraints and the limited access time to the target audience in the case study. Also apart from the survey questionnaires, interview will be conducted with the senior management, technical staff and academic staff to have a detailed view about the adoption of cloud technology and if they have any adoption challenges in the implementation or the usage of the technology in the HE institution.

Chapter VII- The chapter presents the findings of the research and present the data that was collected during the investigation phase of the research. The data is presented in the form of charts, graphs, tables for questionnaire. The qualitative statements were gathered during the interview phase.

Chapter VIII- The chapter provides a detailed discussion about the data collected during the investigation phase from all the stakeholders in the specific HE case study. All stakeholders during the investigation identified various adoption barrier to the use of cloud computing technology in the HE institution. The barriers are due to the absence of the framework that can set standards and act as a benchmark to all the cloud service providers.

Chapter IX- The final chapter provides a detail summary, conclusion and recommendation of the research. The chapter concludes by addressing how the proposed framework solves the adoption barriers in the HE institution. The chapter also provides recommendation and further research area that can be conducted.

CHAPTER 2. Higher Education in the 21st Century Social Changes and Technological Development

2.1 Introduction

The good quality higher education system can revolutionize the countries across the world by producing a skilled labour workforce that can compete with all the challenges in this fast changing world (Bello and Russo, 2016). The importance of higher education cannot be ignored now and in our era. The higher education is considered as a capital investment for the future that will ensure economic, social and welfare development for all the individuals and the country as a whole (Zissis and Lekkas, 2017). The main responsibility of these HE institutions is to provide advanced knowledge and technical skills so these individuals are ready to take key positions of responsibilities (Baker, 2011). For a knowledge based economy to be sustained it needs a highly educated manpower that can use advanced technology and add value to the economy (Chung, 2011). The process of economic development and prosperity cannot be achieved without providing quality of higher education. It is essential for the policy makers to understand the importance of higher education and incorporate it with the demands of the market so that there is a smooth transition of students from a HE institution to the real world without any hurdles (Dill and Vught, 2010).

As already said, for any nation the importance of their educational institutions cannot be ignored. As reinforced by (Doelitzscher et al, 2017), the most important commodity for any state; is the educational institutions of that state that can offer quality education and are a hub of innovation, research and can be catalyst to the economic development. Some authors defend that these HE institutions can have the power to lead, make or destroy the destiny of the nation (Dobbins, et al., 2011). For any nation its strength is determined by the quality of the human resource developed. These institutions are responsible to equip the manpower with the advanced skills that will open new horizons of economic development for a nation (Duan, 2016). The author further reiterates that there is direct linkage between the development of a nation and its educational institutions. This relationship is clearly evident and its importance cannot be ignored. The author emphasis that the HE institutions should evolve and update their curriculum with the integration of science and technology to meet the ever growing

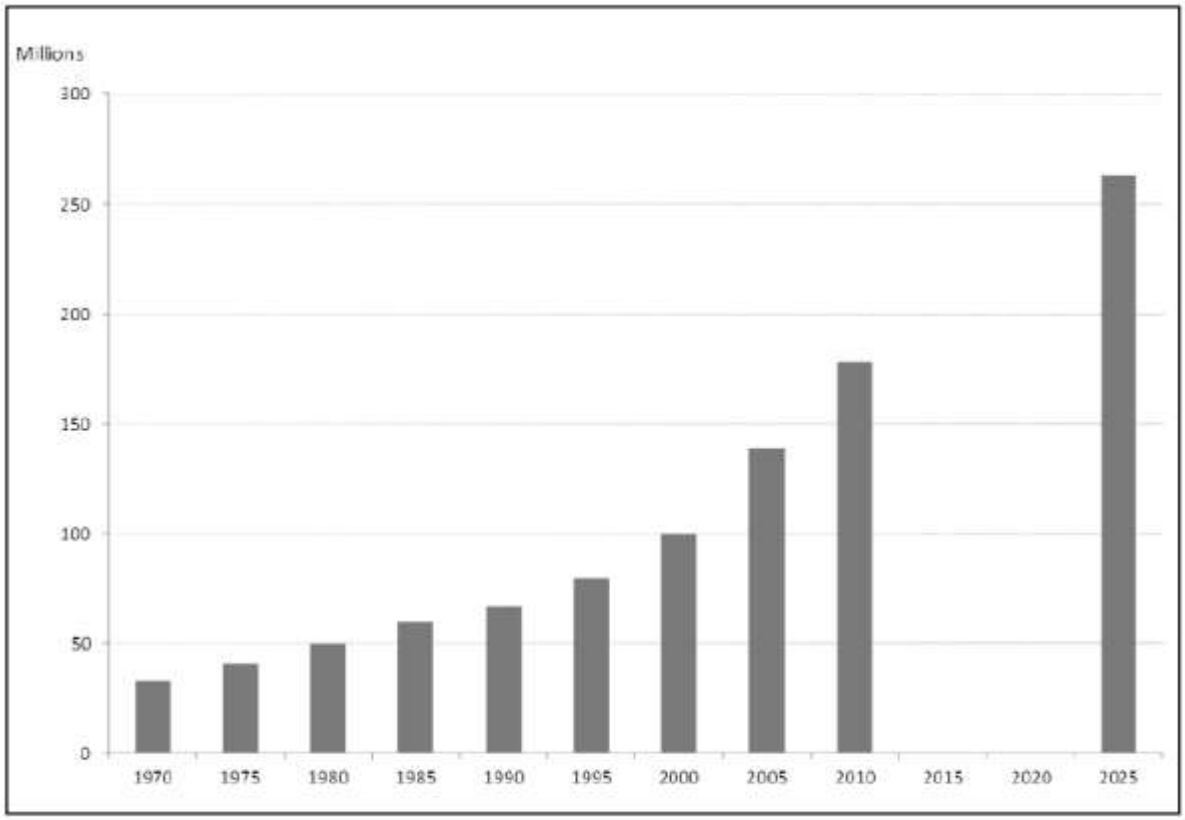
challenges of the 21st century. This chapter discussed in detail the global challenges and trends such as technology that are affecting the higher education across the world.

2.2 Global Challenges and Trend in Higher Education

For a knowledge based economy the skills and human capital plays a vital role in the economic development for any economy in the 21st century. In this competitive arena for any economy or society to make progress it cannot ignore the need of highly educated individuals and use of technology. The nations across the world can achieve and maintain their progress by educating a skilled workforce and giving them the knowhow of the latest technologies. According to (Dill and Beerkens,2016), in order to support the knowledge based economy the higher education plays a critical factor to provide advance skills to the workforce which can bring economic prosperity and development. The higher education that is based around the latest technology has totally revolutionized the agenda across the world and considered one of the most important issues according to (OECD, 2012a). That is the precise reason seeking higher education globally is facing massive upwards trend as reinforced by Altbach, which express that there is an impressive academic revolution that has taken place big in scope and diversity (Altbach et al., 2009)

The higher education due to massive participation has seen a major change itself where the HE institutions were meant and attended by elite in the society only and now these HE institutions are more diversified and cater the need of the entire society regardless of their socio-economic level according to (Hossain, Huang and Yong, 2015). According to the authors, the higher education is facing major changes in terms of huge expansion, more internationalization, and the emergence of new players that bring more competition, use of advanced technology, implementing the new governance structure and increase pressure to improve the quality, increase performance, allowing to integrate technology into academic and accountability across the board. According to the UNESCO Institute for Statistics (UIS), in (2014), there is a dramatic expansion of higher education worldwide as shown from the Figure 2.1. The data presented by the department shows that in 1970, there were approximately 32.5 million students enrolled in the higher education worldwide whereas in 2000, the figure rose to nearly 100 million students enrolled to higher education and in 2010 the number had reached to 178 million students enrolled in higher education. These numbers

show a 4.3% average annual growth in the enrolment at tertiary level which is higher than the 1.6% average annual growth in the world populated as identified by (UNDP, 2012) data. The following figure highlights that the major expansion started in the middle of 1990s, with 5.9% average annual growth in the higher education and according to (British Council and IDP Australia, cited in Davis, 2003 and Douglass, 2012), the number of higher education is forecasted to 263 million by 2025. According to (Abdullah et. al, 2015), there must be multifactor that are underlying in the massive expansion of growth in higher education. The author explains the main reason why we are observing a major expansion is that the public demand and awareness to seek higher education is increasing across the world as there is a realization that education can help to improve the socio-economic development. With technology interconnecting us, social mobility is much easier than before that is also leading to these higher figures in the growth of higher education.



Source: UNESCO Institute for Statistics Data Centre for 1970-2010 and Daniel (2009) for 2025 forecast.

Figure 2.1: UNESCO: Higher Education Forecast (UNESCO, 2011)

According to (Gibbon, 1994; Schofer and Meyer, 2005 and Altbach et al., 2009)**,** a knowledge based economy requires highly skilled workforce that can ensure the smooth transition of post-industrial economies. These authors further states that the accelerated pace of technological change has provided a further boost to the higher growth in the higher

education. According to European Commission report 2010, "Europe 2020 - A European Strategy for Smart, Sustainable and Inclusive Growth" states that higher education has observed massive participations that from United States and Canada in 1960s soon followed by Western Europe and Japan in 1980s. In the last couple of decades all regions across the world are experiencing growth in the higher education with Sub-Saharan Africa (8.4 % average annual growth), the Arab states (7.4%), East Asia and the Pacific (7%), Latin America and Caribbean (6.4%), followed by South and West Asia (6%). The recent figures show an explosive growth in the participation of higher education that is taking place in South and East Asia. According to (OECD, 2012a), the forecast for 2020, there will be 40% of young adults (aged 25-34) will be in the tertiary degree program. In the following section different globalization factors that are affecting the higher education will be discussed in-detail.

2.2.1 Emergence of New Players

With the massive participation of general population into the higher education the need is to provide better quality of education and with more options that can cater the needs and requirements of different individuals and provide them with the higher education that can meet the challenges of the 21st century. In order to respond to the needs of higher participation there is an increased number of higher education providers that are established to respond to these demands (Guri-Rosenblit and Sebkova, 2015). The higher education growth has also introduced different types of institutions within the higher education that provides an alternative to the traditional universities. According to (OECD, 2012), 'Education at a Glance 2012' in the report it indicates that the higher education is experiencing a structural revolution where the need is to have institutions that are strongly employer-based providing hands on experience to the participants which will enable them to integrate into the labour market. There are many examples of these type of institutions which were different from the traditional universities providing an integrated path to the labour market. In OECD, this initiative started in mid 1960s with the creation of IUT (Institute Universitaires de Technologie), followed by 1970s Technical and Further Education Colleges (TAFE) in Australia and Portugal set up Polytechnic Institutions that provided vocational and technical training that can enable individuals to learn skills that according to the employer and job market with hands on experience. This approach provided an alternative to the

traditional model and cater the needs of a large audience resulting in higher participation in education.

These new entrants play a crucial role in providing training to the middle layer professionals needed for knowledge-intensive economies (Golamdin, 2016). These short duration programs with employer required skills training are crucial to meet the growing demands at the manageable costs (Gürüz, 2017). These institutions cater the growing diversification, provide a platform to enable individual to get ready for the labour market and meets the students and employers expectation and desire goals according to (Guri-Rosenblit, and Sebkova, 2015). As there is an ever growing demand for higher education countries have to adopt different approaches to meet the demand. There are large amount of countries who have allowed the private sector to get involved and meet the growing demand. This trend was clearly visible when there is limited public funding in higher education then private sector plays a central role in the public higher education (Douglass and Edelstein, 2009). For example the private sector in India, Latin America and China has seen massive growth in the privatization of higher education to balance resources to meet the challenges of this enormous demand (Goedegebuure, 1994).

The higher education demand is ever increasing and the private sector has to play its role to meet the demand. According to (Dong et al, 2014), the private sector is accounted to 30% of induction across the world. The figures shared by OECD, identifies that Chile, Japan and Korea has the largest private sector and countries such as Portugal, Poland and United States also have a sizeable private sector that are trying to meet the demand of the knowledge economy. These demand is also high outside the OECD, such as Indonesia, Philippines and Malaysia are also having a very large private sector to meet the demand of the higher education. The data highlighted by different studies clearly represent the situation where the is an ever growing demand for higher education and individuals from all walk of life with different demographics are trying to seek higher education. The demand is so much that let alone the government in the public sector cannot fulfil the requirements and in order to cope with the difference between supply and demand the private sector is playing a pivot role across the world. The institutions are providing training so that the skill workforce is ready to

support the economies across the world. The next section will discuss in detail the challenges faced by integration of technology into higher education.

2.2.2 Integration of Technology

Education as any other sector is facing the challenge to incorporate advanced technology to produce a skilled workforce that is capable to meet the industry requirements. These new technological advancements will have a massive influence on the organization and provision of higher education will be also affected across the world (Rayport and Heyward, 2017). One of the severe challenges for the higher education is to cope with and integrate the rapid advancement in communication and social networking technologies into higher education so that students will have full access to these technologies and produce skill labour workforce that can meet the challenges of 21st century. The use of technology is very important in the success of the higher education institutions. The institutions in the last many years have started to integrate technology by using online instructional delivery mode, e-learning system, blended learning, computer simulation and computer modelling tools are being used. As reinforced (Williams et al, 2015), the use of technology is core to the higher education. The technology provides "blended" instructions in which classroom is organized through Internet based student faculty interaction or student to student networking is now the new normal in all the higher education. According to (Webber, 2012), in higher education, Internet based online instructional is being implemented at a very large sector. The higher education are adopting new options such as Massive Open Online Courses (MOOCs), that provides access to advanced courses taught by top faculty to thousands of students across the world. This has open venues to learn but at the same time created more challenges for higher education institutions. The higher education are using the MOOC networks using technologies similar to it where leading universities can contribute and everyone can use facilities to the share of knowledge across the world. The integration of technology in education is allowing the spread of knowhow to all the citizens across the world and provide them with shared opportunities now. These open education resources are involved in the formulation, production and dissemination of the required skills. The use of e-book technology also provides another mode of interaction for these students to learn from new material (Weller, 2006). The report produced for the United States Nation Science Foundation, from (Ouf, Nasr, Helmy, 2011), recommends a new approach to do scientific

research by collaborating across the national and international level closing the geographically distributed research centres and connecting them together using the "e-infra-structure" technology. All scientific teams working together share their experiences using the technology to learn from each other.

The integration of technology in education is expanding rapidly which is catering the needs of adult students by using online delivery mode. This approach is playing a vital role in the social advancement, economic development and cater the needs of the population that cannot use the traditional approach to seek education. As reinforced by (Veeramanickam and Radhika, 2016), integration of technology is helping to collect data about the students which will enable to design individual learning plans for tracking students learning needs using warehousing technologies. Nowadays, the use of data analytics is helping to highlight the key issues student face and design a comprehensive solution that can help students to excel in the learning process. The use of Internet has transform the way we communicate with each other. There is a greater participation of the public using Internet to communicate and learn using online material. The traditional model of the classroom has been changed and the new generation is more familiar with these new technologies which they are using on a daily basis to learn from each other. The integration of technology has led to active participation from people across different age groups, different social economic level and disperse communities so that they build and share knowledge across any boundary. The next section will discuss the large scale internationalization issues, different cultural impacts on the education sector.

2.2.3 Large Scale Internationalization

The internationalization is a comprehensive process that involves the international point of view, integrates all the cultures together and provide global reach to define the purpose and the delivery of tertiary education (Kalpeyeva and Mustafina, 2016). In the last few decades the higher education has seen a major internationalization which has transform the sector. According to (Masud, Huang and Yong, 2015) higher education has experienced international exchange programs, sharing of knowledge and collaboration and there is wide indications of students and academic mobility which is clear reflection of internationalization of higher education. As reinforced by (OECD, 2008) and (OECD, 2012) figures that

internationalization has widened and all the institutions have to consider and include this factor in their strategy. The higher education system is facing wide range of pressure across different quarters. In the past the sector never faced so many challenges but currently the higher education institutions faces a sea shift change over the relationship between the academic culture and the requirements of the labour market (Broucker, Wit and Verhoeven, 2017). The higher education institutions are not only facing a huge mobility of students and academic challenges only but the wave of internationalization there is an impact on educational programs, integration of activities that can lead to providing opportunities to conduct internationalization of learning is also major challenge to overcome. Providing cross-national education that crosses borders mobility and enable to gain skills that can prepare students for the upcoming challenges. The new pattern is emerging where there is growing interconnection of higher education systems and course content from different areas are integrated into different disciplines (Bjarnason et al, 2009).

The process of internationalization has gone through an evolution process itself due to the influencing trends that have emerged. One of these trends is that economies across the world are becoming more interconnected with each other so the need of international experience has become more important for operating at the global scale. This trend has influenced the growing demand on integrating international dimensions and requirements into the education and training skills. The global economic integration and fast tracked the internationalization of higher education institutions to produce a skill workforce with qualifications that are at the same level as international recognized qualification to improve standards and excellence is the main requirement (Broucker, Wit and Verhoeven, 2017). The current rise in the new economy demands more skilled labour workforce. The employers have to look abroad for the talent as there is difference in the supply and demand in the market. So internationalization is becoming an integral part of the long term strategic skills development strategy. There is also a demographic change in some of the OECD countries with the decreasing domestic enrolment. So in order to fill the gap the internationalization is a way to improve those falling numbers. The emerging countries have an insufficient capacity to manage and train their skill workforce and on the other hand in most of the OECD countries there is tertiary education system in oversupply. So in the last many years we are experiencing the deregulation of the higher education in the OECD countries to provide a new education option from these emerging countries. Also the deregulation allows distance learning and cross border options

which has provided a lot of opportunities to seek higher education. This expansion of higher education is so enormous in the scale that has increased the awareness of the value of trade of internationalizing the higher education. The growth of international students' mobility is increasing from last many years and the trend is continuously going to move upwards. According to (Brown et al, 2015), the trend of students' mobility has increased in the last many years due to a high numbers of students from China and India and growth by 2020 is expected to reach 5.8 million and 8 million by 2025. As the following Figure 2.2 highlights the growing trends of number of international student enrolments which clearly shows that internationalization is major challenge and also provides greater opportunities for higher education institutions across the world.

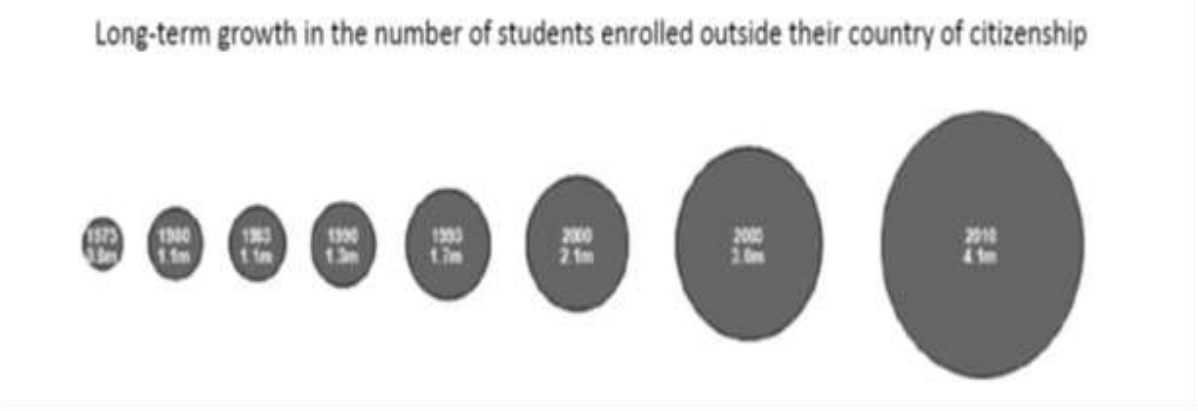


Figure 2.2: Internationalization of Higher Education (1975-2010), in millions (Bologna Ministerial Conference, 2012)

The Bologna Ministerial Conference in Bucharest (2012), set a target that 20% of graduates in Europe have to be trained abroad by 2020 which is a very ambitious target to set. The internationalization of higher education is also experiencing different mobility trends such as short term transfer from one institution to another, just for few days or it can be a long term move for a year or more than that. The exchange of staff and faculty for visit, research and collaboration is very useful to share experiences and take advantages of each other's strengths. The opening up of the higher education institutions for students across the world has experience massive growth. The recent trends show higher education institutions forming partnerships with international partners to open franchise campus is also becoming really popular. The internationalization trend will continue to grow and it will continue to have far reaching impact in upcoming years.

2.2.4 Improving Performance, Quality and accountability in Higher Education

With the diversified and growing number of higher education institutions there is a rise to have set of standards to improve the performance, quality of education and comprehensive accountability across all the section. As the higher education system is becoming complex and further diversified, the centralized control and monitoring systems are vague and not comprehensive to manage the emerging complexities. The need of the hour is to overhaul the higher education steering principles and procedures such as performance, quality and accountability to meet the complex challenges (Dobbins et al, 2011). The monitoring and audit of these principles are crucial to provide new direction to the institutions for the future. There is a great demand to provide autonomy and localized the decision making process at higher education institutions to motivate them to meet the requirements of the labour workforce, economy and the overall society. With more autonomy and decision making powers bring accountability that should be across all level to ensure the quality is improved in the higher education and it should be a cost efficient process according to (OECD, 2008) and (OECD, 2012).

The institutional autonomy can help the management to make decisions effectively. With the autonomy comes accountability for higher education institutions for the use of public funds and brings quality and "value for money" according to the report from OECD (2012). The accountability model provides full authority to the concerned person with define role and responsibilities and then make them accountable for their decision. The accountability model ensures that the strategic leaders have strategic vision, which can reform the institutions and meet the challenges. The most important part of the reform process is the involvement and close monitoring of the communities to have a check on strategic leaders, teachers and administrative staff to ensure that they are serving according to the roles and responsibilities defined and implementing the reform vision to meet student's needs. The senior management in higher education is facing a lot of pressure to improve the standard of quality in teaching and learning, delivery, research and innovation with resources that are limited and demands which are ever increasing. The academic leaders have to show great leadership skills in the decision making process as they are considered as manager, entrepreneurs and team builders (Fogel, 2016). The author further explains that the strategy best suits the needs of the higher education system where the local management should be empowered to ensure the real

reforms are taking place. The strategic leaders and the institutions are held accountable to the communities they serve. This strategy will ensure the accountability take place in the HE institutions because the strategy is focused on transparency, participation, openness, and include everyone with the ownership given to different individuals with proper accountability. The implementation of an accountability model, that can provide solution to the problems such as lack of accountability, confusion between the roles and responsibilities, lack of vision and brings real reforms by introducing financial incentives to the management to overcome problems such as poor quality service, low level performance and not meeting the desires and inspirations of the students and communities they are serving. The autonomy with accountability will provide incentives to the strategic leaders and teachers for better performance and the implementation of the reform vision. According to (Borden and Banta, 1994), the key performance indicators will measure the new model key procedures and principle and various reform agendas are using these key performance indicators to measure the quality improvement in the higher education institutions across the world. There is a demand from the communities and the general public which these higher education institutions serves is to provide better quality, improve performance and with autonomy have detailed accountability.

2.2.5 Focus approach for student centric learning

There is shift in the learning methodology towards the learning-centric approach making student the focus of attention (Cornelius-White, 2007; Weimer, 2002). This change has far reaching impact on the higher education and there is now an evidence that institutions and faculty are ready and adopting the learning-centred philosophy focusing on students and their learning needs (Webber, 2016; Scott, 2015). Whereas in Asia-Pacific region the situation is different and this student centric learning approach methodology is facing huge hurdles (Cheng, 2009). According to the author the challenges can be address by ensuring professional development and focusing on teacher's management issues to implement the policy in an effective manner. In the Bologna conference, it was reinforced that innovative methods of teaching and learning should be used to include students in the learning process will allow to implement the student centric learning methodology (Bologna Secretariat, 2012). Innovation can inspire students to be a part of their learning process and institutions, staff and students together can encourage a rich and innovative learning atmosphere.

The student centred learning approach can be only implemented if new ideas to improve student learning outcome can be tested and tried which will allow students to experience new options and prepared for the real world challenges according to American Psychological Association (1997) and (Brock and Miller, 2007). Still, we need of evidence based research on effective teaching and learning strategies; this needed to be carried out so that more innovation can be incorporated into teaching and learning strategies. (Brock, 2015) have presented numerous evidence of student centred program and intervention that can improve students' learning and outcomes. According to (Liu et al, 2013), focused on introducing a standard outcome framework that is comprehensive and can be used as a benchmark for innovation in teaching and learning, instructional effectiveness that will result in improving student centric learning process.

To improve the student learning and ensure the true implementation of student centric learning methodology all department in the higher education has to play their vital role including student support services. The function of student support service is vital to the students experience and it has vital importance in the teaching function to provide support in the academics and administration. In U.K student support services has a diversified job role that is not limited to career advice and guidance but also includes areas such as disability support, financial support and guidance, exam and classroom preparation support, health and wellbeing and advice on social and family issues as well. According to (Wilkins and Huisman, 2012), the support services varies from institution to institution, whereas the focus of monitoring and delivering is done centrally to improve the students learning experience and promote innovation in the classroom. The implementation of student-centric learning methodology can be fully implemented which will bring innovation, technology enhancement and testing new ideas in the classroom which will provide a rich learning environment for students.

2.2.6 Moved towards competency development, knowledge society and learning outcomes

Higher education can initiate the social and economic change for the policy makers as this is critical area to be investigated further. The importance of higher education that can provide a foundation of the knowledge society is being discussed rigorously by various authors. The competency development and knowledge society will lead to knowledge production and transfer of knowledge across borders which is an integral part of knowledge economies and

social economic prosperity. The higher education that uses innovation and research is in a sounding position to transfer that gained knowledge to the industry and business which will generate economic growth for the wide communities. According to (Webber, 2016), it is evident that scientific research in innovation and technology development is the key functioning role of knowledge and high skilled labour workforce which played a vital role in the post industry development and economic productivity. In the current scenario the importance of higher education institution and the knowledge they generate cannot be ignored according to the author. The author further explains that the institutions play a vital role in the form of research knowledge and a pool of desired skills that are the pillar for the knowledge based society and economic development. The new knowledge produced is replacing the traditional approach as the knowledge gained is helping to resolve all the society issues and challenges (Gibbons et al, 1994). For a knowledge based economy there should be strong partnership between the higher education institutions, industry and the government. (Ismail, 2016) introduced a new concept known as "triple helix" that builds closer relationship and linkage between higher education institutions, industry and government. In the proposed model the higher education institutions will be responsible to bring new development and ideas by using innovation, research and transfer the knowhow. The importance of innovation and high level skills will ensure the competiveness and produce knowledge which can deal with the real problems. The challenge is that higher education institutions have the ability and autonomy to produce knowledge that can be used to effectively to lay the foundation of the knowledge economy.

The competency development using the learning outcomes is a new trend. There is an international drive to benchmark students at higher education institutions based on the learning outcomes across the continent to compare the performance across the borders. According to AHELO Consortium (2011), the higher education institutions will be able to analyse the data and information on the university achievement based on the learning outcomes. The major initiatives includes Times of Higher Education World University Ranking (TSL Education, 2011) and Academic Ranking of World Universities (Shanghai Jiao Tong University, 2011) which can act as a benchmark to compare the performances cross institutional which is an emerging global trend. These new global trends are having a major impact on higher education institutions. In order to meet all the above challenges the

institutions have to evolve, innovate and improve teaching and learning to produce a skill workforce that is capable to meet the challenges of the 21st century.

2.2.7 The changing role of state in Higher Education

In the last many years there is clear evidence that government is trying to reduce their role in the delivery of economy and higher education as well. (Kim, 2009), identifies a clear pattern where there is a reduction in the role of the government and autonomy is given to the institutions to take a leading role in managing all the strategic and operational issue. With this reduced role of the government to provide education there are serious questions raised mostly in the developing countries. As the author explains further, that the role of state to provide higher education was by default; and with the change the private sectors getting involved to offer education is matter of concern for some audience as they were under the impression that only the state was responsible to offer higher education.

The higher education like any other sector has faced market failures and requires a direct intervention of the market. According to (Katz et al, 2015) the government needs to intervene and set guidelines for all the stakeholder so that sector can perform. We have experienced the near collapse of the bank sector in the Western world where a normal person cannot borrow from the banks and faces isolation in the market. Then the government intervenes to provide some solution to these problems. The higher education like any other sector will require direct or sometime indirect intervention by the government to regulate the market, state new policy to ensure smooth running of all stakeholders, manage funding, monitor and audit all the higher education systems. The state role is to define a legal framework which has a set of polices defined to manage and govern the educational institutions. This can be a huge challenge to define the legal framework and then ensure that all stakeholders abide by that legal structure. In a report published by UNESCO (2014), "Global Education Digest 2014", the institutional independence is very crucial for a higher educational institution to innovate and provide services according to the inspirations of that particular community they are serving. In the case of political interference this can lead to slowing the innovation agenda and, by itself, political interference can affect the institutional in a negative manner. The same report also states that by providing autonomy to higher education, government will have more competitions among these institutions. Higher education institutions will improve their

quality to attract more students and more investment in better facilities and research can ensure to produce a workforce that is highly skilled according to the markets requirements. The report also recommends that government should not dictate the pay scale of the faculty but this should be controlled by the institutions. As we are experiencing a huge enrolment of students in higher education, the government funded higher education institutions cannot cope with this demand. There a pressure on the state to open up the education sector so that private sector can also get involved to provide higher education. There can be tax incentive to encourage the private higher education system. There are many models that can be used to encourage this process. For e.g. the American tax provision allows tax free donation towards higher education and research. There can be government matching program for each donation made to the higher education by the individual (Pampaka, Hutcheson and Williams, 2014). The government has to allow the private sector to plays its full role in delivering higher education and provide an atmosphere for competition and innovation.

2.3. Looking in the Past and future: The evolving structure of U.K Higher Education.

The higher education in the United Kingdom has a very impressive history. In the historical context of Oxford University that is considered as one of the oldest educational institutions as teaching is documented from 1096. The University of Cambridge celebrated their 800th anniversary in 2009 and celebrated all academic staff that came to the town in 1209 to preach education. Across the border Scotland has educational institutions such as St Andrews, Aberdeen and Glasgow that was established in the 15th century and the University of Edinburgh start functioning in 1583. In the mid, 19th century United Kingdom (UK) experienced a massive scale expansion of higher education institutions, medical and engineering institutions which lay down the foundation of a knowledge society (at that time, was the 'engine' that fuels up the beginning of the industrialisation phase) based on the principles of innovation and entrepreneurship, economic generation and meeting the demands of the general public. In the mid-1950s and 1960s due to massive demand of an ever growing population the UK expanded the higher education system and advanced technology institutions were established across the country such as Aston, Bath and Salford, among many others. In early 1990s, the Further and Higher Education Act was passed which allowed the polytechnics to change their status and become universities. With massive economic development in the early 2000s, the country was able to establish 31 universities in the first

of decade of the new century to meet the very growing demand of national and international students.

The higher education is provided in more than 166 institutions and they are allowed to issue their own degrees as well. These institutions meet the strict criteria set by the central government. In UK apart from degree awarding higher education institutions there are more 1600 bodies and colleges that can offer higher education options. The UK higher education system is totally a market based system where universities have separate identity protected by law having full autonomy to award degrees. These institutions are public funded for teaching and the major cost of teaching is met from tuition fees or government grants. Due to market based approach there is a lot of competition between institutions to improve on the quality of education, teaching and learning practices, providing more research opportunities, more program options for students, competitive price and awards. As reinforced by (Shiau, Chao and Chou, 2017), the best model to increased efficiency is that government gets academic services from the main service producers and then students can achieve all the services on subsidized option. There are private higher education institutions and if students decide to enrol in these institutions then there can less cost burden for the government. To gain higher education there are enormous benefit for the individual and the overall society. In order to achieve those benefits of seeking higher education and achieving the criteria for both efficiency and equity the individual and their families have to make some contributions towards the cost of achieving all these benefits (Pole et al, 2017). The UK higher education market has been developed by lowering the entry barrier and tried to promote the supply side competition between institutions to provide more options for the individual to decide where they would like to get higher education. The UK government in order to bring competition between institutions and improve the quality of education introduced many initiative such as funding research that is monitored by peer review process, introduction of student loans, maintenance grants, use of top-up fees, implementation of key performance indicators to monitor the performance of the institutions and promote more competition and quality. All these initiative have provided students with more choices and access to better quality of education in UK.

2.3.1 UK higher education sector

The higher education institutions are not managed by the government as there is a decentralized structure where the governing boards manage all the institutions. These higher education institutions are totally independent and protected by law and the governing board is responsible to set the strategic direction of the institution. The institutions have autonomy to make decisions and are held responsible for the financial performance, quality of teaching and learning, research and all issues related to the institutions. The major theme of 2003 white paper "The future of Higher Education" (Department for Education and Skills, 2003), the focus was to increase the reputation and image of teaching in the higher education in UK. By increasing the public awareness of teachers and higher education institutions, more people will be attracted towards higher education sector leading to a knowledge based economy.

In the 1980s, the UK education system was divided into universities, teacher raining colleges and polytechnics and technical colleges. Some of these institutions were directly funded by various departments such as Cranfield Institute of Technology and many others. Whereas universities were funded by University Grants Committee. The polytechnics and colleges funded through sponsoring local education authorities and national funding system. All the universities are free to offer any program or award any degree which provides a same playing competition field for all the institutions. The UK education sector seen another change in the 1980s when the teacher training colleges became the part of large institutions so that they can function effectively. Also the polytechnics were evolved and they became universities (Taggart, 2004). After this evolution the major challenge that was faced was that existing universities were not ready to reduce their prices when the government introduced bidding for marginal places. The current status is that all universities are a part of a single market and are equal to each other and can compete with each other to attract more students. In order to fund the higher education institutions in sector the government has established a separate entity known as "Funding Councils for England, Scotland and Wales" which is an autonomous in their decision making process for financial support and provide support and advice to all institutions (HEFCE, 2014). There are more than 166 higher education institutions in the UK and they are eligible for government funding for teaching and research. The private institutions cannot access the government funding but they are allowed to access funds via Student Loans. All the institutions can employee their own staff and the pay of each

staff is determined by the pay scale already determined between the management of the institutions and the trade unions.

The UK higher education is of a considerable size and with the increase in the size of income there is an increase in the size of students enrolling into the higher education institutions. Also UK is attracting a large amount of international students as well. As the following Figure 2.3 highlights, that with higher incomes more individuals are opting for higher education with the increased number of students.

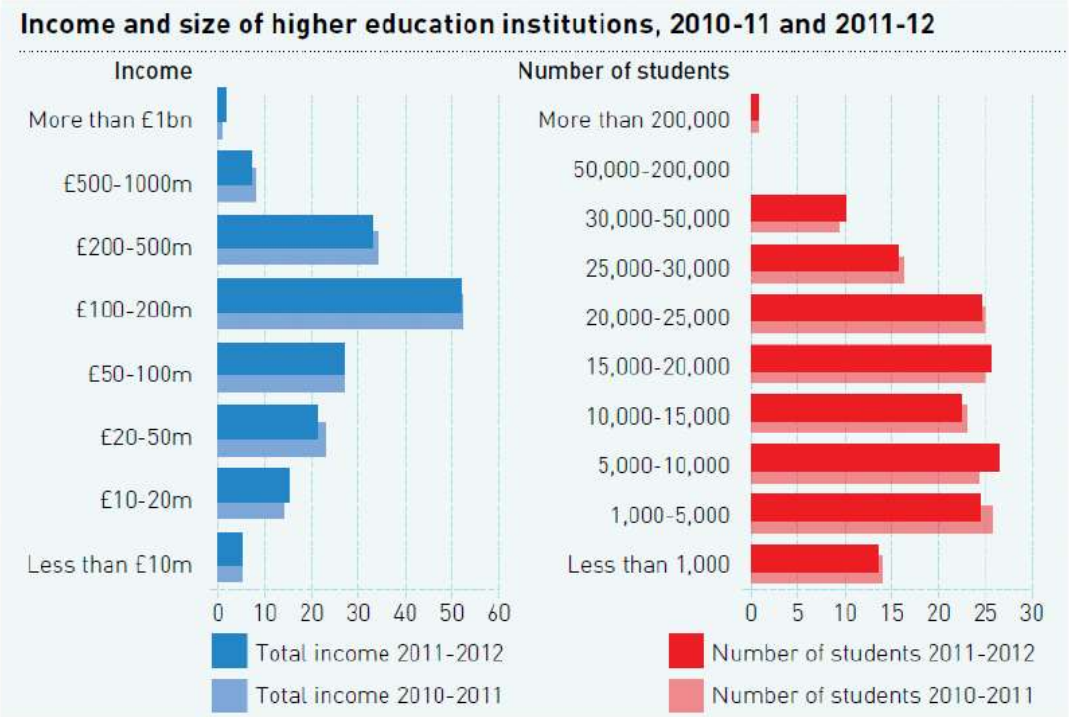


Figure 2.3: Increase income and size of higher education institutions (Wilkins, S. and J. Huisman, 2012)

2.3.2 UK Higher Education: Growth in Student numbers

With more public awareness there is higher number of individuals seeking higher education in UK from the last few decades. According to the Department for Education and Skills (2003), it was only 3% of tertiary-age students in UK entered higher education in 1950. This figure jumped to 8% in 1970 and by 2001 it had reached 40%. As the Figure 2.4 shows there was further dramatic increase of 50% of students going to higher education in 2011-12 who have completed their tertiary education. The figure clearly shows an increase number of students seeking higher education.

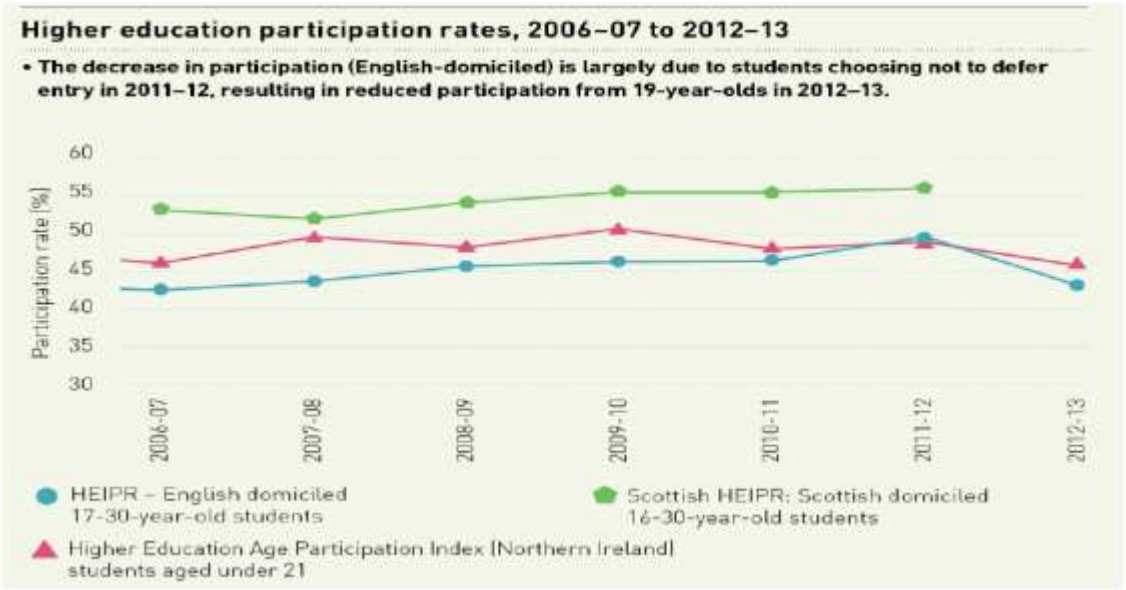


Figure 2.4: UK Higher Education Participation rate ((Wilkins, S. and J. Huisman, 2012)

There is an increase in the total number of UK students according to the Department of Education and skills from 1.6 million in 1994-5 to more than 2.3 million in 2013. There is clearly upwards trend to get involved in the higher education. The following Figure 2.5 also highlights the increase number for full-time enrolment whereas decline in the part-time enrolment in U.K higher education institutions between 2003 and 2013. The Brexit effect is not clear if it impacted this trend so far.

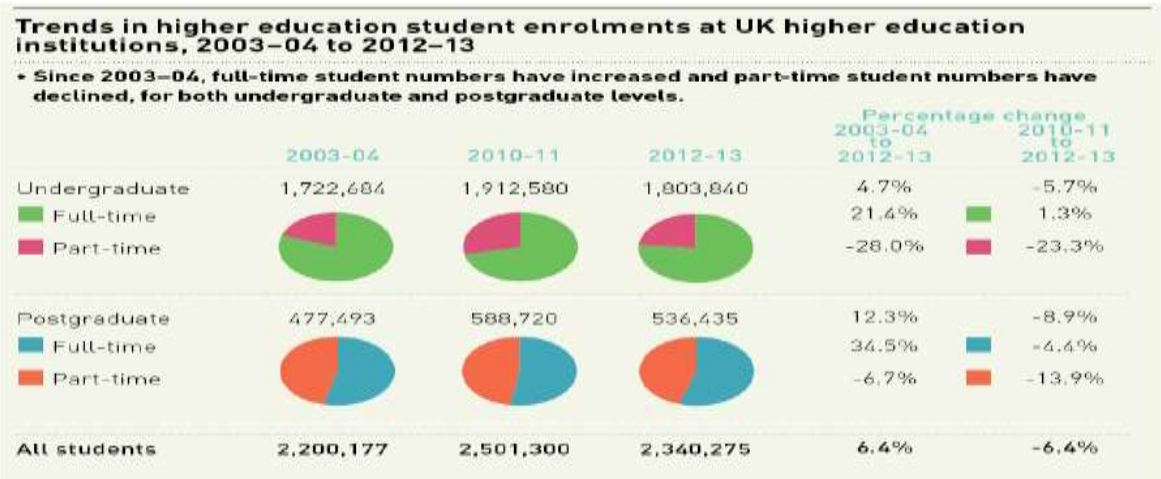


Figure 2.5: UK Trends in Higher Education Enrolment ((Wilkins, S. and J. Huisman, 2012)

2.3.3 Higher Education: Admission Process, Course Structure and Future

All higher education institutions are independent to set minimum criteria for the admission process in UK (Evans, K, et al. 2009). In order to ensure the smooth running of the admission process, there is a central control system known as UCAS (Universities and Colleges Admission Services). This service deals with mostly undergraduate students who are trying to get admission to the higher education. Whereas for post graduates and international students they apply directly to the institutions. The normal degree program is finished in three years whereas courses that have practical element or professional degrees will take longer than normal. The postgraduate programs are finished in one year whereas research based post-graduate programs are finished in two years' time. The higher education offers vocational degree programs such as Higher National Diploma (HND), Higher National Certificate (HNC) and the Diploma in Higher Education (Dip HE). The qualifications such as Postgraduate Certificate in Education (PGCE) and Graduate Teachers Program (GTP) are one year programs.

To improve quality of education, the UK government has introduced now initiatives in 2012 that will bring more competition among various higher education institutions for funding. The competition will be more severe as private institutions are allowed to compete as well in the higher education with access to the public funds now. As reinforced by Times of Higher Education in January (Baker, 2015), the higher education institutions are facing a lot of competition to attract students from UK, EU and international students, but the government believes that the education market should be more open to attract more competition which will results in better quality of education. In order to promote more competition the new initiative is introduced where private "for profit" institutions can compete as well. The private funded higher education institutions such as University of Buckingham and Royal Agricultural College will bring more competition in higher education that will result in improving the quality of education and provide students with more options. To promote more competition for the future there is a reduction of direct public funding and finances who are directed through the students' fee system (Bekhradnia and Massy, 2009). Higher education institutions have to attract more students by providing better quality of teaching and learning facilities, more course to choose from and better research facilities. These new initiative will introduced more providers, degree differentiation and further deregulation to have the level

playing field for all the providers. These new initiatives shows there is a complete shift in the delivering of the higher education going into the future in UK and provides education for all. The real change will be only effective and implemented if the new providers play their role in the market. These providers have to be diversified and introduced viable option for the students.

2.4. Higher Education and Role of Information Technology

According to (Anjali and Pandey, 2014), higher education institutions across the globe are facing immense pressure to evolve and incorporate latest technological innovations. These new technological innovations will change the way the higher education institutions deliver the education to the students. The author further explains that various options are available such as providing distance education, online learning management systems and form collaboration with different research partners around the world using technology. Using technology in higher education has lots of benefits but at the same time technology is considered as disruptive innovation that can be expensive also needs a social and public awareness. The use of information technology is becoming an integral part of delivering education. The faculty members need to change their teaching style and learn how to use the technology in the classroom. This exercise will require a lot of time where the faculty needs extra training and budget to ensure the incorporation of technology into higher education.

The use of technology will continue to increase in the delivering of education. Due to the technological innovation there is direct influence of technology on various teaching methodologies (Su, 2016). The author explains that the higher education institutions that offers technological mode of delivering of education will attract more students. A large portion of institutions are using technology to offer distance learning education to a wider audience. With the use of technology various institutions are working in collaboration to do research while geographically dispersed across the globe. These online learning courses provide a great opportunity to learn for those who are not able to access these institutions and resources. The use of technology will promote corporate academic partnership which will be beneficial for educational institutions to have real world experience, promote research with the corporate world, and locate more funding for the higher education institution. The partnership between the corporate world and higher education institutions will only be

beneficial if the higher education uses advanced technologies and at the same time they show a long-term commitment to the use of technology.

The use of technology in the higher education institutions can build an ecosystem of innovation and research that can lead to a positive impact for research and development (Shahzad, A. 2016). On the other side of the argument the large scale use of technology in the higher education can have operational and logistics challenges that can create hinderers in the adoption of the new approach. The faculty will need a lot of support, training and motivation to use the technology also the overall need of change in the organizational practices is required so that new technologies can be adopted (Shiau, Chao and Chou, 2017). We are living in the technological oriented knowledge economy and there is a huge burden on these higher education institutions to produce students with the quality of education that is equipped with advanced skills and technology to meet the challenges of the real world. To achieve this objective the use of technology should be incorporated into higher education.

2.5 Knowledge Society: Open Information, Open Content, Open Source

We are a part of global village that is based on the basic fundamental; that a society is based on rules and principles and is highly skilled and knowledgeable. Every society with the passage of time has experienced social and economic changes. These changes can be managed in an effective manner if we have higher education institutions that are a hub of innovation and technology advancement. The pressure on a society is overwhelming and the path of a global economy and knowledge society that is open to everyone and all information can be easily available and shared has its own challenges and implications. (Beerkens and Dill, 2016). The focus of these societies is to provide advanced skills to their individuals so that they contribute to this knowledge society in an effective manner. The highly skilled individual from these higher educational institutions will become a part of knowledge society that will lead to knowledge economy providing abundant opportunities for everyone to succeed and achieve their inspirations. There is a clear difference between societies that are based on sound foundations of knowledge than those who are not. The knowledge society will have the ability and skills to bring effective change at the grass root level by introducing new initiatives, sharing innovation, use of advanced technology and inspiring each other to improve at the institutional level (Brown et al, 2015). The knowledge society is based on

some key principles that are the part of the model. These principles ensure the ideas of transparency, accountability, openness to share ideas, deregulation, encourage the use of technology and innovation where the state provides an ecosystem that allows everyone to work freely and interact with each other without any political interference (Brown, 2010).

In a well-structured article knowledge society discourse and higher education by (Bjarnason, et al, 2009), the importance of knowledge to a post-industrial society cannot be ignored. Knowledge plays a crucial role to scientific research, innovation and technology and highly skilled workforce can increase the economic productivity (Brock, 2015). The key role in all this is the higher education institutions and quality of skilled labour workforce they produce. The author further explains that the traditional notion of the higher education in knowledge production is under an immense challenge whereas for a knowledge economy it is integral to have sound supply of knowledge production and transfer of this knowledge mechanism. The knowledge production can only take place with advanced research in the higher education institutions and the same knowledge is transferred to the industry and the business world to use that knowledge to solve a real world problem. The knowledge economy where the demands are challenging and ever-changing the employers require a unique set of skills to manage all these pressures. Traditional set of skills will be inadequate to manage these challenges. As reinforced by (Brennan, 1997) to meet these diverse challenges we need a workforce that possess unique set of skills such as interpersonal skills, problem solving ability, advocacy and policy formulation capability, effective communication and teamwork capacity. For a knowledge economy the workforce should be creative and critical thinkers in their thought process and have social skills with familiarity of different cultures and background to effectively converse with anyone across the globe.

2.5.1 Knowledge Economy: The Open Context

The knowledge economy can flourish if the environment is open to share information and all diverse communities play their vital role in the production and transfer of the knowledge across each other. Nowadays this concept can be effectively implemented due to the invaluable contribution played via Internet. The Internet as a medium provide a great value of service by allowing the production and sharing of information and knowledge that is vital for

a knowledge based economy. Internet provides an open platform that is accessible to everyone and provides equal opportunities to everyone to share and access information. (Douglass et al, 2012) open educational content can follow and implement the traditional library structure where all the material is available on the Internet and World Wide Web. This platform can be used by anyone to share knowledge to anyone across the geographically divide. For a knowledge economy these mediums such as Wikipedia is an example of an open educational platform where knowledge can be shared among all the users.

2.5.2 Knowledge Economy: The Open Source Software and Standards

The next key principle that ensures the knowledge economy can function properly is apply the term "shareware" where the software is available of free or at a very low cost so that more and more people can use that application to create more knowledge. This initiative allows mass population to be a part of revolutions by using these software and should not be at the side-lines due to their disadvantage background. There are many examples which allow shareware such as Linux operating system and Moodle learning system that are based on the open model solution which is available for everyone. Any educational institute regardless of their size and budget can use this model which is not too expensive and provide opportunity to everyone to be a part of a knowledge based economy by removing any barriers and isolations. These open source software provide more choices to the end users and provide a solid foundation to a knowledge economy by providing real benefits to the educate everyone in the society. The knowledge economy needs openly available standards that can ensure the smooth transfer of data and information. The purpose of these open standards is to prevent "locked into" a particular system situation where the end user has no other option to explore. The purpose of these standards to ensure that user has wide options available and they can move from one application to another without any barriers to do so. This will improve quality and competitions which are required for a knowledge economy to progress further.

2.5.3 Knowledge Economy: Open Science and Open Educational Content

The main cardinal of a knowledge economy is based on extensive research and development in the field of science and technology. A knowledge economy will thrive with the ambitious project as open science where the researchers will conduct their latest research and all their

findings are shared across the research community and the general public. This will initiate an ecosystem of further research and generate more activity by using the findings of one study to jump start the next research. The project open science can also allow researchers across the world to comments and provide feedback on the data collected from this research. This process will validate the concepts and improve the efficiency and make major progress in the field of research and technology. The Internet can ensure the implementation of Open Science model and promote more collaboration and specialized research communities to share and take advantage of their experiences.

Due to the growing connectivity there is a major requirement on the academic community to provide teaching and learning data online so that it can be shared across the community. All material such as presentation, handouts, notes, exercises that are shared in a traditional classroom should be shared over the Internet so that everyone can take advantage of this online material. Various educational institutions can play a vital role to share educational material such as OpenCourse Ware initiatives from MIT which enable learners to access all educational material across different parts of the world. These initiatives are promoting higher education institutions to be more innovative in their processes and ensure that they can collaborate across any geographical divide to produce a skilled workforce that can be part of knowledge economy. The role of higher educations is to pioneer in the change process and introduce innovation and technology. These institutions should be catalyst of change and should remove any barriers in the way of change management. As reinforced by (Green, 2016) the higher education institution should evolve and be a source of stability and transformation rather than to take external or internal pressure to stop the transformation process. There are serious economic conditions that the world economies are facing and it has an effect on the higher education institutions with tight budget. There are massive capitalist forces which will impose their agenda on the higher education institutions. These capitalist force require a total submission by following a total non-practical framework. The main focus of these institutions should be to set their own criteria based on the market demand and always ensure the integration of innovation and technology to produce a product which can play a vital role in the society.

2.6 Higher Education and use of Cloud Computing

The higher education institutions needs to integrate advanced technologies so that quality of teaching can be improved. The higher education institutions are facing a massive influence of disruptive technologies and cloud computing is one of them (Kalpeyeva and Mustafina, 2016). With the use of cloud computing in the higher education institutions it will allow the collaboration, sharing and production of information much easier. Higher education institutions are living in the digital age of information technology that requires the adaption of these services to meet the demands of the market and address the domestic issues such as reduction in the budget. The higher educational institutions need a lot of public funding and with the current economic constraints the finances are not enough to meet all the requirements according to (Ercan, 2010). There is a growing demand for IT services in these higher education institutions so that it can support educational, research and development activities with limited resources available. In order to meet these challenges there a shift towards cloud-based application as reinforced by (Gartner, 2016), there is a big shift towards cloud based application. In the global 1000 companies more than 50% are storing their confidential data in the public cloud. This trend shows new learning requirements from students who want to access data while they are mobile.

The use of these advanced technologies in the higher education are providing a high quality of education so that the workforce is produced with advanced skills to meet the challenges of 21st century (Wu, Garg and Buyya, 2016). The education institutions that incorporates the cloud based system will allow the productions and sharing of knowledge which will have a far reaching impact on social, economic, cultural and technological development. This transformation can only take place if there is a use of technology in education which will create new venues for education, research and development according to the author. The use of cloud computing in the higher education has a significant impact and there is an evolution of the adaption of the technology is taking place. The use of disruptive technology has completely changed the way in which higher education institution and industry operate. In order to compete with the new challenges higher education institutions need to adapt to these latest technologies to stay competitive and attract more students. The new generation students are known as “digital natives” (Mathew, 2017), these students have grown up using all the advanced technologies such as social network forums and are familiar with the cloud based model as well, By using cloud computing model in the higher education institutions there will

be a reduced IT expenditure. The cloud model provides a greater flexibility for the faculty, students and employees for higher education institutions as the data is available to all the stakeholders whenever they want and at any location they can easily access data in the cloud (EDUCAUSE, 2009b). The cloud computing used in the higher education institutions will transform the way the work in performed. As we see there is a transformational technological shift where we can transfer our business from the local data centres towards cloud storage. The cloud option is becoming the requirements for the higher educational institutions. Using cloud computing option can provide more uptime, reliability, reduce technical failures, provide a clear payment plan and reduce cost (EDCAUSE, 2010a). As the following Figure 2.6 identifies cloud computing and various service models that can help and assist various business functions according to their requirements.

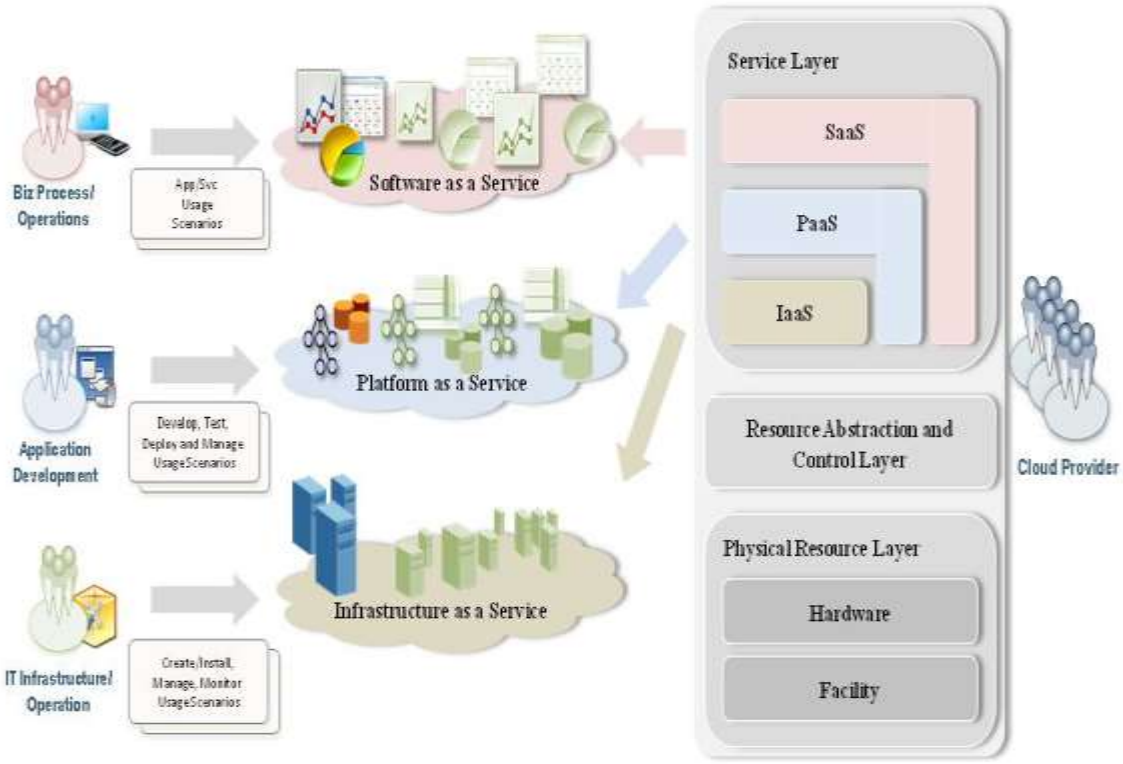


Figure 2.6: The Cloud Computing and Service Models (NIST, 2009)

The understanding and use of advanced technologies is vital in the education. The importance of understanding the benefits and the use of cloud computing in higher education cannot be neglected. For a long term strategy; the higher education institutions need to incorporate

cloud computing technology in their plans that they can compete effectively. The use of cloud computing technology in the higher education will initiate a solid foundation to manage research and innovation across the world by sharing research data, build an ecosystem of innovation, use other disruptive technologies such as big data analytics, and manage administrative and financial transaction, mobile and wireless communication with flexibility and reduce cost on the infrastructure (Rady, 2015).

The use of cloud computing in the higher education will allow easy access to the limited IT experts and talent. At the same time use the cloud model; we can increase or decrease the required resources based on the actual demand (Hofmann and Woods, 2016). The benefits of using cloud computing at a higher education will allow the institutions across the world to share and exchange research and ideas in an effective manner by using advanced technologies. This will promote the IT standards and allow to address the ad hoc arrangements that are conducted by the technical support team for ever changing IT services. The model promotes a transparent method to compare the quality of service offered, IT costs, security standards and funding requirements. It allow to reduce the initial capital to setup an IT support systems and ensure supporting model for 365 days in year with exceptional up time that is not available at a local data centre managed by any educational institution themselves. The use of a cloud model in the higher education will reduce the cost and provide resiliency and redundancy to the service (Pampaka et al, 2014). The technology will provide higher education institution with scalability, better performance, backup and easy implementation with the increased storage capacity at a minimal cost as compared to the traditional model (Herbert and Erickson, 2009). With the list of benefits the higher education institution should consider the weaknesses and limitation of using a cloud based technology. There are always concerns about the cloud technology which in some cases cannot run all the applications due to interoperability issues with the platform (Baranwal and Vidyarthi, 2016). Large amount of potential users are not opting for the cloud service due to the variable standards in terms of security and privacy issues of the data that is stored on data centers where the customer have no access (Holzinger, Röcker and Ziefle, 2015). There are serious concerns about the security of data which can lead to the failure of using the service (Hill and Westbrook, 1997). Due to lack of security of data there are challenges related to the confidentiality, integrity, accountability and authenticity of the data which can be very detrimental to the confidence of the cloud users and providers. Also there is a weak control

on the provider and there are different security standards that are deployed due to weak uniform standards. This can lead to various types of attacks such as Man-in-the-Middle, DOS (Denial of Service), DDOS (Distributed Denial of Service Attack) which can affect the availability of the service and the whole operations comes to a halt (Amazon Web Service, 2014). Serious issues with cloud computing has been raised such as various data breaches have taken place in the past, insider attacks, data segregation issues in the cloud model and weak or no standards for a quality services are the concerns that are a major hurdle in the implementation of cloud computing model.

2.7 Summary

The main purpose of this chapter is to provide a background to the need of higher education and use of technology that allows for innovation. The chapter reflects on key challenges of globalization and how the higher education institutions should adapt and evolve to these ever growing trends. The above chapters also provides an insight into the UK higher education institution structure and the changes which UK education sector has seen in the last many years. The chapter also emphasises on the need of seeking quality education, integration of technology into higher education and design a knowledge economy but this also requires the improvement of higher education institutions. The chapter also discussed the use technology and innovation in higher education and list the challenges that have to be addressed by these type of institutions so that can produce a skill workforce according to the demand of the market. The chapter also discussed the use of cloud computing in these higher education which is generating a lot of discussion in terms of the immense benefits this technology can bring to these higher education institutions; spread education to the end-users in an effective manner.

CHAPTER 3. The Cloud Computing: Characteristics, Service, Model and Business Requirements and Adoption Challenges

3.1 Introduction

With the current global environment, we are experiencing exceptional challenges and constraints in the financial system across the world. The global economics is showing a downwards trend that is having an impact on all other sectors. In the last many years the budget has been tighten so there is an urgent need by the senior management to explore all venues to manage the resources in an effective manner. Due to the economic crisis the world financial system is facing turmoil and its repercussion will continue to be felt in the next many decades to come. The crisis has put the government and private organizations finances under massive constraints and the money available for each sector is less than ever before. All institutions are receiving less funds and the urgent need is to reduce the operating cost and improve efficiency across the operations. All institutions regardless of which sector they operate have to review their internal processes and propose ways to reduce the cost of day to day running operations in this environment where there is limited budget. The higher education institutions are facing the budget reduction similar to other sectors. In order to meet the changing needs the higher education institutions have to evolve and integrate the technology into their operations. In this situation cloud computing is a suitable option which has limited budget requirement in terms of the initial capital investment, reduces operating cost and overheads by providing unlimited benefits such as flexibility, reduce cost and offers customers to pay as use basis that can save a lot of capital and operational cost of the organization. The introduction of cloud computing has seen a massive reception from various educational institutions and users looking forward to using the technology and reap benefits. In this ever challenging world, the demand of cloud computing is showing a massive increase with more and more users adopting this technology. The model provides a flexible approach that charge customer on their usage only and allows scalability to meet the changing resource requirements. The cloud solution provides a new approach to the working by using cloud applications, software and the experience for the end user is as normal without any noticeable change the way they work. Using cloud as a solution provides instant setup infrastructure with minimum capital investment upfront and tries to provide a flexible solution for its users. In the following chapter, the study will explore in detail the cloud computing technology by initially providing the cloud development history and will discuss various implementation

models, different types of services offered by cloud computing and discuss the cloud model characteristics such as quality, economic and technical. The next section of the chapter compares cloud technology with similar technologies and provide the reader with a detail explanation. The chapter provides an insight into the various commercial cloud products that are in the markets and critically analyse each commercial products in the market. Then the next part of the chapters discussed in detail the major adoption challenges for cloud computing that are considered as barriers in the adoption of the technology. For the ease of the reader these adoption challenges are subdivided into technical barriers, institutional and environmental barriers. The last sections provide an insight of cloud computing on various key industries.

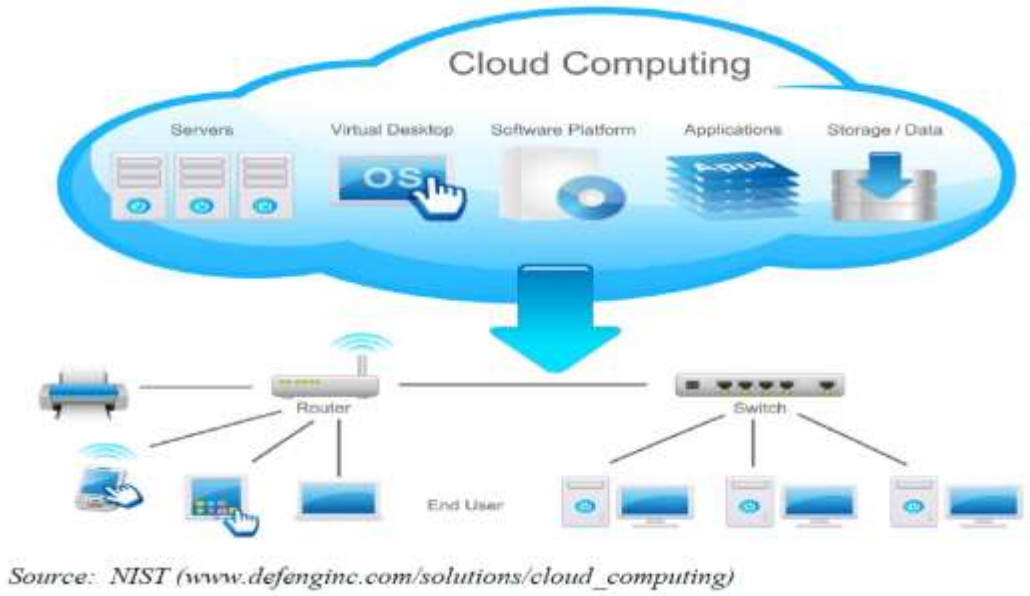
3.2 Introduction to Cloud Computing

The cloud computing is a disruptive technology and with its introduction since 2007, the word Cloud has received a major attention from all the stakeholders across all the industries. The 'pundits' predict that the technology will revolutionize the way we work forever. Various researchers have pondered large amount of time defining the term cloud computing for an average user but still there is a lack of consensus on this term. As mentioned by (Alabbadi, 2016), cloud computing provide a distributed infrastructure containing a large pool of resources, such as storage, processing power and services that are released based on the demand of their end users. The author tries to distinguish the features of cloud computing from distributed computing structure. In the cloud model all resources are virtualized; and resources are scalable to meet the surge of demand and also it can be reduced if the demand is reduced. The model is driven by economics of scale which can reduce the overall cost and improve the efficiency.

According to (Gartner, 2016) cloud technology is scalable and provides an elastic ability to various customers that are disperse across the geographical divide by using Internet. NIST (2009), defines the cloud computing model that provides convenience by providing resources that are based on the demand. There is shared pool of resources that can be quickly issued or released with a low level involvement from the cloud provider. This model is intelligent and respond to the end-user demands in an effective manner. (Saidhbi and Shaik, 2016) explain the cloud model that consist of very big pool of resources that can be easily used based on their requirements. Resources in the shared pool are programmed to reconfigure according to

the different load requirements. This features allows optimization of resources and reduce the overall operating cost as well. The end user is charged based on their usage and these resources are guaranteed by the service level agreement between the cloud providers and cloud users. According to (Marinela and Anca, 2016), explain cloud computing offers a combination of parallel and distributed computing; resources are virtualized and provided dynamically allocated resources according to the requirements of the end users. These requirements are agreed in advanced after detailed discussion that forms a set of terms and conditions known as service level agreements that has be followed by all the stakeholders (Bayya et al, 2009).

The definition of cloud computing is difficult to agree as the technology has a lot of popularity and different authors have provided explanation but agreeing on a standard definition seems to be a difficult task. As (Doelitzscher et al, 2017) and (Dong, Zheng et al, 2009), describes cloud computing as a technology that provides access to the services, data, and various applications via Internet. Whereas (Mell and Grance, 2011), defines the technology as flexible that provide resources from the shared pool based on the demand. The resources can be dynamically allocated according to the needs of end users and there is a minimal involvement from the management. (Youseff et al, 2015) defines cloud computing technology similar to peer-to-peer network and provide virtualization of all resources. According to (More, Vij, and Mukhopadhyay, 2017) states the technology is a mirror of grid computing infrastructure which is an extension of cluster computing. The model has proven to save money, provide a reliable option, and as an organization you do not have to invest a capital trying to buy all the infrastructure. According to (Clark, Warnier and Brazier, 2016), cloud computing is experiencing the massive growth that resembles the growth seen by the computing industry. As seen from the Figure 3.1 cloud computing model is adapting new standards and with the passage of each day as it is improving the underlying technology infrastructure by managing servers, providing virtual desktops, processing data and managing applications. The Internet penetration is wide and the trend continues to rise, the machines that are produced are having huge process powers than ever before, the cost to storage has reduced allowing users to store a large amount of data. All these factors are contributing to migrate towards the cloud.



Source: NIST (www.defenginc.com/solutions/cloud_computing)

Figure 3.1: NIST Cloud Computing Model (NIST, 2009)

The cloud computing is a great innovation that is having impact on all other sectors. Using the model, we can share and collaborate across the geographical divide and reach those areas where information technology was not able to reach before. (Srinivasan and Getov, 2014), report identifies clearly that there is paradigm shift in the delivery and use of information technology and it will impact all our lives. The technology is being implemented across different sectors now and having a huge impact the way we used to interact with information technology.

3.2.1 Cloud Development History

The concept of cloud computing is not new and it has initiated the new trend in the field of technology providing commercial benefits to all the businesses. It is evident that the technology is successful in making a strong foothold in the market and it will continue to play its vital role in the next many years to come. Amazon was the pioneer in the design and development of the cloud computing and were the first organization to rent their infrastructure to the external customers for data storage and use of applications. Amazon was the first organization to introduced cloud computing to the end users in the form of Amazon EC2 and S3. Followed by various other providers such as Microsoft, Google, HP and Yahoo that are in the cloud market now providing the cloud users multiple options that is improving competitions and quality of services.

The cloud computing is attracting a lot of attention from different researchers and academic across the world. A new initiative was launched known as Academic Cloud Computing Initiative (ACCI), between a large amount of universities and big cloud providers such as Google and IBM to discuss and resolve the key issues in cloud computing. After this various other projects have started such as Eucalyptus and OpenNebula to provide a cloud solution according to the cloud users. Due to these open source projects new implementation models for cloud computing were introduced such as private cloud for a specific organization that needs high data security and hybrid cloud model was introduced to meet the cloud user's requirements of combining different service models. The cloud computing in 2010 was able to achieve a new milestone with the introduction of 'SiteonMobile' launched by HP. The Figure 3.2 shows the development history of the cloud computing.

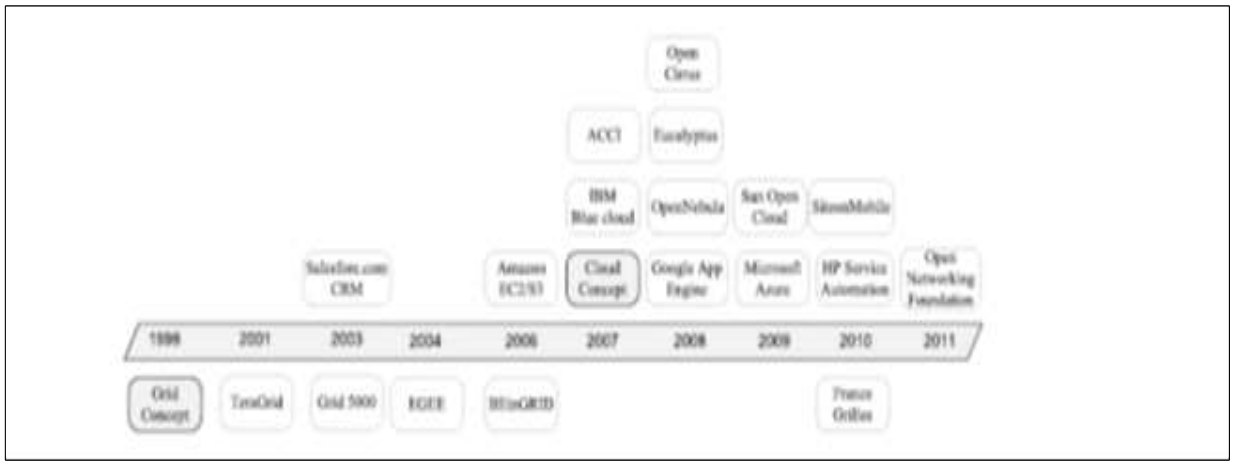


Figure 3.2: The Development History of Cloud Computing (Golden, B, 2010)

The cloud computing model catered the needs of the changing customer who wanted to use Internet by using their mobile phones rather than the computer. This model promoted mobile computing where the end user can take their data with them and access it anywhere they want. In March, 2011, marks another milestone in the history of cloud computing where a non-profit organization called 'Open Networking Foundation', started to boost innovation by making small software changed so that all networks and various components can work together in an effective manner to provide better quality of services to the end users. The cloud computing model continues to evolve and change in order to meet the requirements of the cloud users and ever changing requirements of the market.

3.2.2 Cloud Computing: System Layout

The cloud computing model provide virtualized resources that can be provisioned according to the demand of the end-users. The allocation of resources is elastic and scalable depending on the utilization of the resources. As stated by (Zhao et al, 2009), there are protocols that will ensure all the cloud computing functions work as normal. The underlying architecture of cloud computing has four layers as shown in the following Figure 3.3.

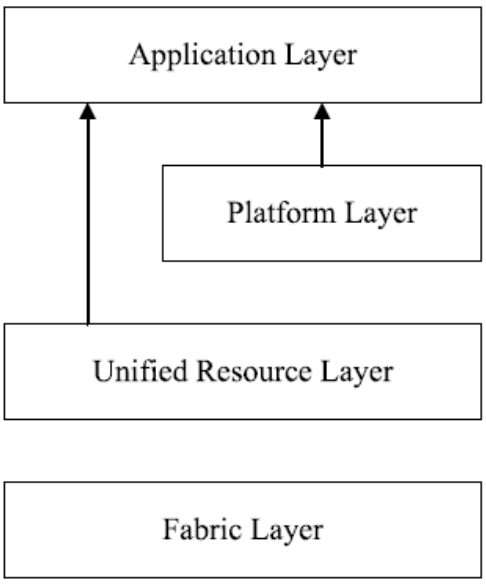


Figure 3.3 Architecture of Cloud Computing (CSA, 2009)

The Fabric Layer is the engine for the model that contains all the hardware resources such as data centre storage facility, processing power and network infrastructures resources that are essential to the smooth running of the cloud computing model. The next layer Unified Resource layer is providing a virtual image of all the hardware and software resources to the end user of cloud computing. The end users can interact with the Unified Resource layer and make virtual images of different resources as required based on their demand (Taha et al, 2014). The author explains that the Platform Layer is responsible for the entire development of different application. This layer sits on the top of unified resource layer and act as a middleware having tools that are special to ensure the development and deployment can be carried out smoothly. On the top of all the layers is the application layer that the end user interact with it directly and all these applications have a presence over the Internet.

3.3 Different Implementation Models

The cloud computing has different models and these are for specific end user' requirements. According to the research conducted (Sandhu, 2013), the new technology is a combination of a series of items such as virtualization, utility computing, flexibility, elasticity, storage, content outsourcing, pay as you go service and provision of services according to the end user demands. The cloud computing deployment model can be seen from the following Figure 3.4. In the next section various cloud computing deployment models will be explained.

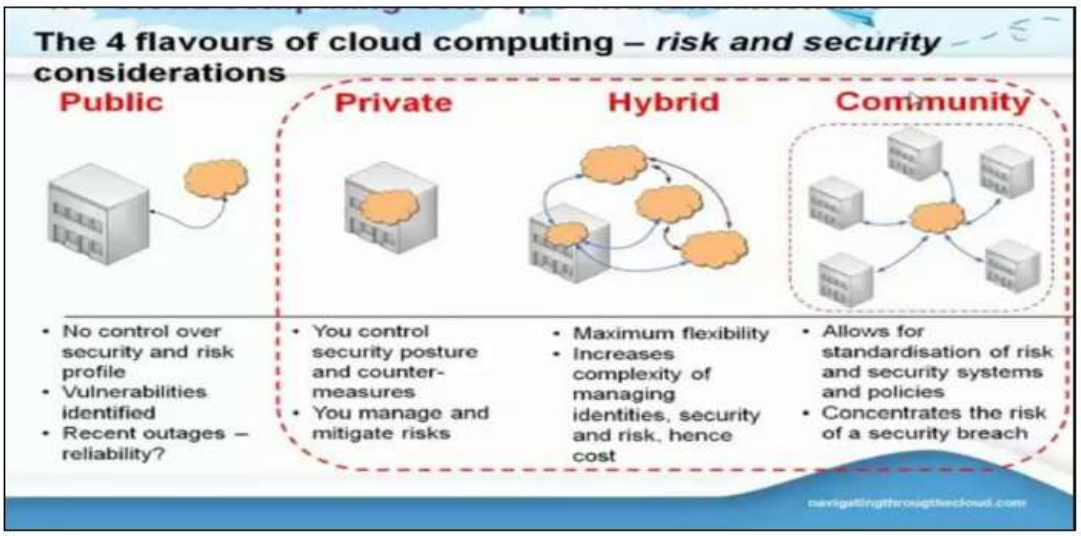


Figure 3.4: The Cloud Deployment Model (Dong B, Zheng Q et al, 2009)

3.3.1 Public Cloud

This model provides resources for everyone. In the public cloud model the resources such as various applications, storage of data is accessible to everyone in the public. Public using this service through Internet. The public cloud is controlled and managed by the organization and the service are provisioned based on demand using the Web application over the Internet. This model is meant for the general public but has drawbacks as the public cloud is considered less secure as it lacks the control and management features. The public cloud is limited with security control over data and network that can be exploited internal or external (Ercan, 2010).

3.3.2 Private Cloud

With the public cloud facing issues in terms of security and various reports of data breaches; a new model was required that can provide an extra layer of security and only meant for a specific organization (Khaitan and McCalley, 2015). Authorized staff can have access to this internal secure network. This model provide an extra layer of security to protect the organization data and ensures all authorized users can access the resources. The private cloud with security also provide a complete control and reduce cost to the owner. (Cavus and Munyavi, 2016) provides a detail comparison between the private and public cloud option. The author explains the private cloud is more secure that provides better control over who can access the resources as compared to the public model.

3.3.3 Hybrid Cloud

As mentioned by (Bilal et al, 2017), this model provides a combination of public and private cloud model together to support the IT organizations. The model provides a virtual IT model that combines both private and public models that offers standard services such as sharing resources, storage space and offers the virtualization. The model is considered as more secure as it can control all resources (Clark, Warnier, Brazier et al, 2016).

3.3.4 Community Cloud

The community cloud is meant for provides secure infrastructure for organization who have similar needs or security concerns. This model is nearly similar as Grid model as various organizations with similar security threats, missions and objectives would like to have a private community to share the underlying resources. These organization prefer to use community cloud and share these resources over the private cloud as they have set security requirements and policies to follow.

3.4 Cloud Computing: Service Model offered

The cloud computing offers different service models which were introduced based on a huge demand of the customers so they can have solution that it tailored to their needs. Businesses need a flexible option that does not strict them in the selection of the type of service or the provider. The end users want to access data in a totally different manner than the traditional

approach of a static position. Now the end user is on the move and want their data to come along with them. As stated by Marc Benoff, CEO of Salesforce.com, based on the demand of our customer we are moving to the next level by providing all these services model that are tailored to the specific customer's requirements. He further explains that the customer wants a complete freedom from the traditional model of complete control of mainframes and client server software. The next difficult choice for the customer is to select the best service model that can meet the set requirements. Here you will need a lot of understanding and knowledge about the description of each cloud service model offers and compare that with the list of requirements for the best match. In order to meet customers' variable requirements, the cloud model offers various services model such as Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) as seen from the Figure 3.5. There are more services that are being added but here we will focus on the main service model and each of them will be explained in detail in the following sections.

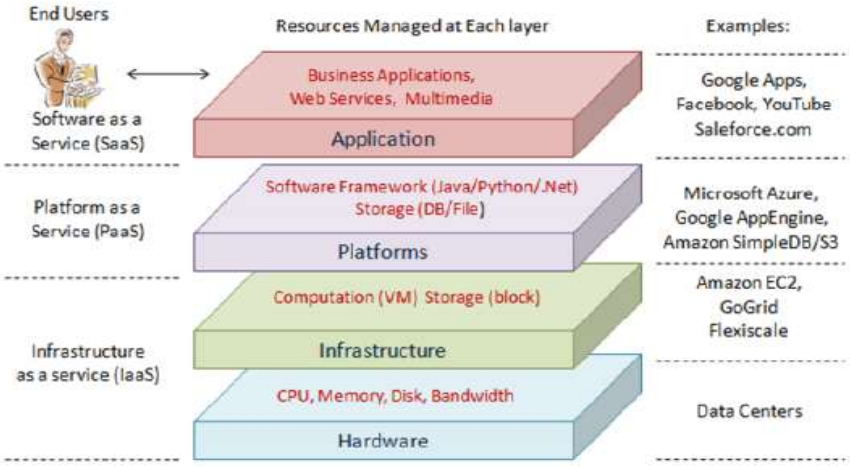


Figure 3.5: Cloud Computing: Service Models (NIST, 2009)

3.4.1 Infrastructure as a Service

In the cloud service model there are various layers which help the consumer to decide the level of resources required. These layers reduce the time, money and effort required by the consumer to build and implement the system. The Figure 3.6 shows the cloud computing stack at the lower end of the normal network room containing all the servers and hardware devices. This model acts as the engine of the machine and provide the ability to store the

data, process the data and provide network of connections to ensure smooth operations as shown from the following figure.

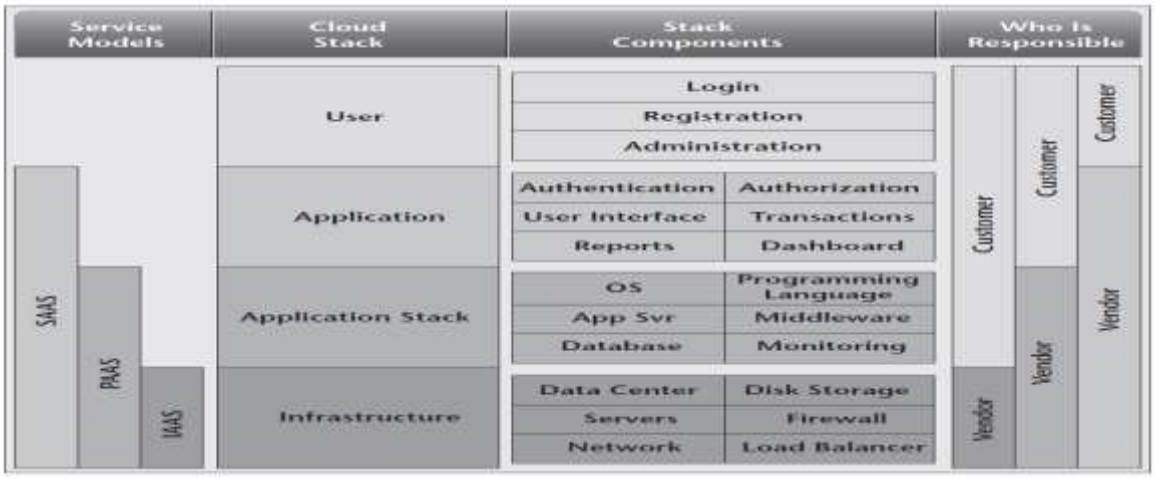


Figure 3.6: The Cloud Stack (Golamdin, 2016)

The consumers can install their applications and software's on the top of this layer. This layer provides an ability to provide resources from a shared pool based on the demand of the consumers. At this level the consumers don't have any interaction with the underlying infrastructure such as server (Song, 2016). The end users in the model interacts with using the operating system to lead the entire operation, managing the storage of data, installed various applications with limited control over various network devices. According to NIST (2009), the IaaS model provides a virtualized environment with all infrastructure required to run the operations such as networks, servers, data storage ability, load balance to balance the traffic and various network components. If the consumers want to start a new enterprise this model provides a great flexibility because they do not need to invest a huge capital upfront to have their own data centres. Using the web based management interface the consumers can control the physical data centre but the programmers at the consumer end are still responsible to build programs and network manager is still responsible to secure the applications. With this model the consumers does not need to manage and control the data centre. The model provides a great flexibility as there is no need all these expensive hardware devices which used to be delayed for a very long time.

The IaaS offers a virtual on demand structure that can be operational without any delay by using the web based interface (Armbrust, et al, 2009). The model is convenient, flexible and efficient which provide a service that was the demand of the consumers from a very long time. The consumer is charged based on the usage policy and when the service is stopped the

consumer is not charged anything which bring a very cost effective solution. In the market various IaaS models are operational such as Amazon Web Service, GoGrid and many more which are allowing many enterprises to start their operation with minimum capital investment and with great ease.

3.4.2 Platform as a Service

This layer is responsible to manage and host all the applications. In the Platform as a Service (PaaS), this layer is functioning on the top of IaaS and ensure the implementation of all the applications without the investment to buying all the hardware equipment required in the data centre and software with provisioning hosting facility. According to (He Luo et al, 2016), this layer contains all the applications, various different coding languages, libraries and other functions managed by the provider. In this model the consumer will not manage any network devices or data centre. This service is very useful for software development houses where programmer is writing long complex programming codes for high scaling systems. The programming code is complex require a series of large computation, caching and other processes that are highly memory intense. According to CSA (Cloud Security Alliance, 2009), PaaS model provide an access via Internet where the provider can release all the tools required by the consumer for the programming and development purposes. The model does not provide the consumer with any control to the technical low level software issues such as memory allocations and other major issues such as stack processing. The provider controls all these software issues and also control the processing power that has to be allocated to each consumer in an effective and a fair way.

The PaaS market is really competitive now with various provider options such as Microsoft Azure, Google Apps Engine and many more are competing to win over the business. There are new market entrants for PaaS has created a flexible and open platform where consumers has a freedom to implement a PaaS model of their preferences. Cloud Security Alliance further explains that various options are available such as PHP, Ruby, Python and the consumer can select any option they prefer. This open platform allows various developers to select third party applications by triggering the APIs and avoid the entire procurement and implementation process that will save a lot of time. The PaaS service model is getting improved and it shows a large scope of various sectors to take advantage of this technology.

3.4.3 Software as a Service

In the cloud stack the layer which operates on the top of all the other layer is known as Software as a Service. The consumers interact directly with the application manages the application related configuration whereas the service provider is responsible to manage all the infrastructure and all development and deployment tasks underneath the SaaS layer (Fox et al, 2015). Various SaaS examples are Enterprise Resource Planning (ERP) systems and for application in various sectors such as education, marketing, human resource management and many more are operational now. The consumers who opt for SaaS model do not have the ability or do not prefer managing all the infrastructure and manage the maintenance responsibilities. These applications can be accessed from interfaces such as Web browsers and the consumer is not responsible to manage the data centre technology. In the following Figure 3.7, explains different cloud services offered by the cloud computing model.

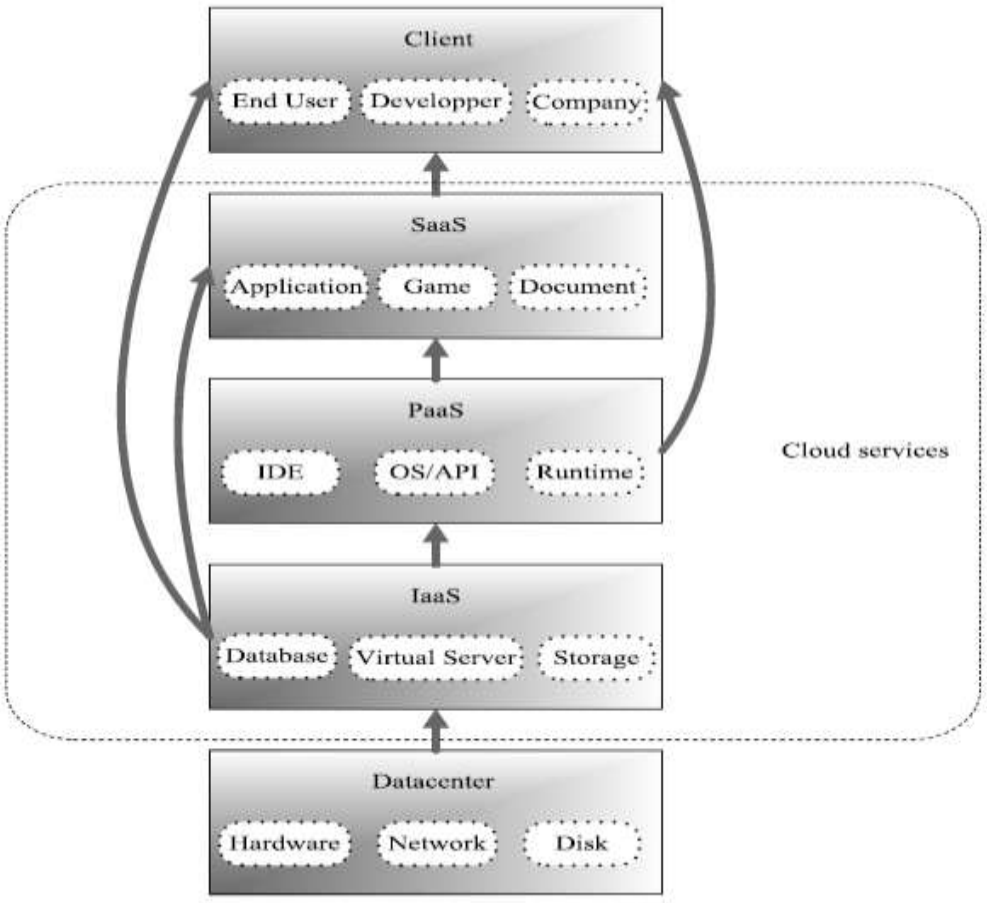


Figure 3.7 Cloud Provides and Service Offered (NIST, 2009)

3.4.3 Security as a Service

The model promotes outsourcing of security service management to a professional third party organization. The model allows security of applications which involves anti-virus software delivered through internet. In this model security management is carried out for in-house assets by the third party organization. The model ensures continuous virus preventions through latest scans and updates. In the model outsourcing of the administrative tasks such as network monitoring, virus identification, eradication and log management is outsourced which will result in saving a large amount of time, money and allow the management to focus on the main areas of the organization. Security-as-a-service provider operate in the same way as SaaS providers, charge monthly subscription fee to reduce cost burden for outsourcing services. The provider ensures the protection for the organization's apps, data and operations that are functioning in cloud. The service provide protection against data loss, regulatory compliance violation, compromised credentials, hacked APIs, Advanced Persistent Threats (APTs), Hijacked accounts or traffic analysis attack, DoS and DDos attacks. The SECaaS provider will protect against any vulnerability without investing large sums and provide integrated services with the existing infrastructure. The use of Cloud Access Security Brokerage (CASB) are integrated into SECaaS environment, which provides a range of services designed to help the organization protect cloud infrastructure and data. The model ensures better security, faster user provisioning, email security, website and apps security, ensures single sign-on and provides a comprehensive security compliance and assurance standards that allows the organization to defend against internet or external threats. According to Gartner Consultancy (2018), www.gartner.com, the cloud-based security controls for applications such as anti-virus, anti-spam programs would generate 60% of the revenue in that industry sector by 2020, up from 20% in 2016.

3.5 The Cloud Model: Technical, Qualitative and Economic prospectus

The organization planning to explore the cloud computing option have to compare all aspects such as technical, qualitative and economic strengths before they can make a final decision to deploy the cloud computing model. It is crucial for any consumers to understand all these issues in an effective manner to make a final decision. In the following section the study will explore all these aspects which will have an impact on the consumer choices.

3.5.1 Technical Prospectus

Any technology before its adoption need to be tested that is it technical a viable working solution. Technical aspect provides a guarantee to the consumer that the adoption of this service will be smooth without any technical glitch and bring economic rewards for taking this risk. Same is true about the cloud computing technical details as well. The study in the next section will examine all the technical issues in the cloud computing that should be considered before the actual deployment.

3.5.1.1 Virtualization

In the cloud model virtualization is a crucial technology which provides a virtual image for all the hardware resources such as servers, platforms, storage devices and various applications to the end user based on demand which is scalable. The virtualization is a user friendly feature because it does not show any technical low level system details to the cloud consumers (Li et al, 2017). The author further explains that the technology provides an opportunity to manage all the network hardware resources in an effective manner. This virtual environment provides a lot of flexibility to the user by running various applications at the same time which are independent of each other. Using the virtualization provides scalability and elasticity and share resources according to the demand. Virtualization provides data recovery procedure as data is stored and backup is done on a regular interval.

3.5.1.2 Multi-Tenancy Agreement

The cloud model provides multi-tenancy agreement where more than one user data is stored at the same storage platform allowing multiple users to share storage resources. Due to multi-tenancy the cloud computing cost is reduce to the fraction of cost as compared to the traditional storage. The feature allows great financial and operational benefits for the cloud provider; where multiple user’s data can be stored centrally that can not only reduce the cost

of storage but also the resources can be utilized effectively. The centralized control will enable the cloud provider to manage the high load time effectively and require less resources to manage these operations. The data which is stored at the same storage location needs a complete data segregation and all data should be isolated from each other to ensure data confidentiality and security is maintained using multi-tenancy option (Baranwal and Vidyarthi, 2016).

3.5.1.3 Data Security Challenges

In the cloud computing model data security is a major concern for all the stakeholders involved. The importance of data security cannot be ignored as we are dealing with confidential data. The reputation of the cloud provider and the overall cloud technology is at stake if data cannot be secured while using cloud computing. It is essential to secure the cloud model just like any other information system by carrying out a detail SWOT analysis, listing all threats and weakness that need a solution to protect against those threats. This approach will allow to identify the security weaknesses and provide security controls to maintain the CIAA triad (Confidentiality, Integrity, Availability and Authentication). The data stored on the cloud should completely segregated and data backup and recovery mechanism should be in-place to avoid any loss of data due to disaster. (Srinivasan and Getov, 2014), explains the cloud model offers large amount of benefits including the management of security, redundancy and higher availability but at the same time serious security challenges to the cloud model are affecting the availability of resources, raising the reliability issues, data integrity and lack of privacy and weak third party auditing procedures are the major concerns for the cloud computing model.

In the cloud model there are multiple users involved with a large amount of network components and applications. With the increased number of parties, end points, devices there is a large amount of points from where the data can be accessed. There are serious concerns as there are so many parties involved in securing the data in the cloud computing model that the data can be breached and its confidentiality and security and privacy gets compromised (Sultan, 2013). The deployment of cloud computing model consists of data security issues such as an unauthorized access to the data which can be exploited due to the flaw in the application design or weak identification procedures which is considered as data security challenges.

3.5.2 The Quality Prospectus

The cloud computing offers a series of quality traits which are a key attraction to the potential cloud users. The technology has shown a huge impact and was able to solve many historical challenges and problems.

3.5.2.1 Elasticity

The cloud computing offers an elastic model that release computing resources based on the demand of the end user without any interaction from management. This provision of services is going to adjust automatically and resources are released or closed from the shared pool in a real-time (Rajkumar, Venugopal and Malpan, 2009). The model is so fine-tuned that it measures the services very closely and offers these services to match the demand of the users. The main purpose is to allocate the right amount of resources to the requirement and do not over or under allocate.

3.5.2.2 Scalability

The cloud model provides a scalable solution to the infrastructure with the minimal need of the management. Scalable solution means that based on the requirement new nodes will be included or dropped from the network with very minimal changes in the infrastructure and minimal changes to the software. (Stewart and Shen, 2015), states that the cloud model can scale horizontal or vertical while scaling to meet the end user requirements. This features promotes heterogeneous platforms in which the location is independent meaning the customer have no information about the precise location and resources but can only identify the information at the high level such as identify the location of the data centre or country.

3.5.2.3 Availability

The cloud computing model provides exceptional uptime and all the services are available for the end user. The availability rate is way higher than the traditional model where the Quality of Service for throughput and response time has to be given set guarantees according to the Service Level Agreement (SLA). The cloud model offers redundant backup system to ensure this exceptional 99.999% availability rate according to (Eisa et al, 2016).

3.5.2.4 Agility

The cloud model provision resources based on demand from a shared pool. The cloud model has to be agile in order to respond to any requirement changes that are taking place online.

The cloud model should have the ability to self-manage by provision and re-provision resources based on the demand.

3.5.2.5 Reliability

The cloud model was introduced with the promise to ensure reliability and the services are always available for the cloud users. The cloud model has various redundant sites that ensure the reliability of the cloud model where the business continues to function and possess a suitable disaster recovery plan that is built into the structure of the cloud model. The cloud model is a reliable option and the probability of losing data or services is reduced due to multiple sites involved in the storage and backup of the data. With the model losing data has very fewer chances and that is the reason more users are attracted towards the model.

3.5.2.6 Economic of Scale and Cost Efficient

The cloud model ensures its implementation is at a very big scale so with its massive deployment it can ensure economies of scale. The cloud model data centres are strategically places in those areas where electricity is very cheap or in the proximity of the affordable power stations to reduce the operational cost. The model provides an affordable subscription that charges customers based on their usage and it ensure a cost efficient solution for the cloud consumers (Zissis and Lekkas, 2015).

3.5.3 Economic Prospectus

The cloud computing model offers great economic benefits for all the stakeholders involved in the process. In the competitive commercial market, the model provides not only technological advantages to the users but also offers exceptional saving and opportunities to make money from this model for cloud providers and consumers. In the following section the study will explore economic highlights of using cloud computing.

3.5.3.1 Pay-as-you-use

The cloud model is really attractive as it does not require a major capital investment to start the operations. The model is based on the subscription pay as you use basis. The consumers will only be charged with the amount of service used. In the old traditional model, the business need a large amount of capital investment to acquire all the network components, servers, data storage devices and software before any operations can start. This was a major

hurdle for many businesses and consumers which do not have enough capital or manpower to manager the traditional model's complexities. With the cloud computing model, it completely decreases the capital investment required for the infrastructure also reduces the cost of procurement, logistic and maintenance (Dill and Beerkens, 2016). The model is really suitable for small or medium sized businesses that do not have enough capital to invest upfront or having skill shortage issues to manage the complex technical operations.

3.5.3.2 Day-to-Day Expenditure

Using the cloud model the day to day cost is reduced dramatically as compared to the traditional model (Duan et al, 2016). The consumers does not have to buy the expensive network devices as they are hosting their data on the infrastructure of the cloud provider. There is a massive cost saving as the cloud consumer don't have to hire skilled IT workforce which can be very expensive and using the cloud model they require minimal IT skills to ensure that the business is connected to the cloud provider. The operational cost is also reduced because the customers are charged only for the amount of service they will use. When they do not use a particular service then there will be no charge which reduced a lot of cost and provides a convenient model for its users.

3.5.3.3 Reduce Energy Consumption

The cloud model is structured and administrated centrally so the carbon emission and energy utilization can be controlled easily from one location. If there is less demand from the cloud consumers, then various parts of data centre can be switched off to save energy consumption. The cloud model allows the efficient use of energy and helps to reduce the carbon emission and performs way better than the traditional model.

3.6 Comparison with similar Technologies

The ever changing competitive global market need a technology to reduce cost, provides flexible scalable model that contains dynamic computing features to support the end user. After the transformation from the virtualization and utility computing a new model is required that offers a reliable model that offer cost effective solution that allows dynamically allocated resources from the shared pool when it is required. The following section of the study will compare the similar technologies and explain the evolution that has taken place in all these models.

3.6.1 Utility Computing

The term ‘Utility Computing’ offers a model similar to the public utility model that we are all familiar with such as public telephone system or metered services such as electricity, gas or water. The idea was presented in 1960s by John McCarthy, in which the idea was proposed to move towards a computer utility model that charges customer on their usage just similar to the traditional meter service. The more you use a service the more you have to pay for the service. (Yang, Shanmugasundaram, and Yerneni, 2016), the utility model offers an opportunity to use the service straightaway without any delay and also does not require the initial capital investment to start the operations. The idea got a lot of popularity in the 1960s but after sometime it was evident that the technology is not ready to cope with this new model. There is a clear reflection of this model on today’s technologies such as grid and cloud computing.

The utility computing model provides a virtualized environment where the processing power to manage multiple tasks at the same time with high throughput is far more than the single time-sharing computer (NIST, 2012). The technology was offering an increasing processing speed as compared to the traditional approach. Then in the 1990s, HP introduced the ‘Utility Data Center’ and ‘PolyServe Inc’ that introduced a new billing structure and cluster system that provided a high availability and was able to distribute the workload. It is clearly evident that the perceived model set the foundation to the emerging technologies such as Grid Computing and Cloud Computing.

3.6.2 Grid Computing

The Grid computing model is a combination of parallel and distributed system infrastructure that integrates web service with object oriented coding to offer sharing of resources that are geographically distributed to provide an excellent quality of services (Zhu et al, 2016). The author further explains the technology that is a combination of computers that are in a cluster in which various machines perform tasks as a virtual mainframe and super machines to manage multiple tasks together. The model to manage a task affectively, distribute the tasks into small sections and work simultaneously on these small sections (Yang et al, 2016). The technology has seen a huge evolution from ‘FAFNER’ that was the initial generational model to ‘GLOBUS’, that is the resource management model that allocates resources and also

maintains the scheduling of all these resources. The latest generation model such as (WSRF, OGSI), provides a combination of grid computing and Web service technologies and offers services to the consumers (Mell and Grance, 2011).

3.6.3 Autonomic Computing

(Gutte and Deshpande, 2015) state that IBM proposed autonomic computing that perform tasks which are according to the set policies. The model is adaptable because the policies will determine the jobs that will get executed with priority rather than the fixed code program. The author explains the model address the increasing complexities of managing various heterogeneous and distributed computing systems and this has resulted in removing the barrier of complexity to further growth. The autonomic computing model is a self-managed model based on various agents and they are managed centrally which is resulted in the reduce cost and manage the service in an effective manner. IBM further explains the functions of the model by stating that the model is self-manageable which gives the ability to configure all the devices automatically and monitors all the resources because it has the ability to self-heal. The model provides self-optimization ability to monitor and optimized the resources and self-protection features are built in by identifying and protecting against the attacks. The model only needs the set of policies and information defined by the users and the model will adapt to the new changes itself (Hurwitz, Bloor and Kaufman, 2015). All these models have incorporated the grid technology into their models by offering independence and autonomic qualities. According to the author the next logical step was the introduction of cloud computing model that can integrate grid-utility model to meet the consumers demand.

3.7 Cloud and Commercial Adoption

The cloud computing model offer a complete shift from storing data in the organization personal data centre to third party provider which will charge the consumer based on their usage of resources. Various cloud projects are competing in the market for their share such as Amazon Web Service, Microsoft Azure, IMB SmartCloud, Force.com, Google Apps and many more. In the next section various cloud market competitors and the service they offered will be discussed.

3.7.1 Amazon EC2

Amazon was the pioneer in the design of the cloud solution in early 2002. Amazon EC2 was based on virtualized technology allowing the end user to make a virtual image or an instance of any resource they require to perform a task. These instances are a virtual image that contains a software for the end user to interact and perform the task. Also the hardware ensures the smooth processing of that particular instance (Amazon, 2014). These instance are having separate sections such as standard, high memory and high CPU, among other. The model ensure security for access management and allows data to be processed at multi sites.

3.7.2 Amazon S3

The new model improved on the deficiencies of the old model by provide a huge storage capability that allows the cloud consumer to easily store or retrieve data over the Internet (Amazon, 2014). This new feature is very important for organization that want to perform big data analytics or developers that require a more scalable option. The model provides reliability as all the data is stored on redundant sites and in case if the data ca not be retrieved from one site then the mirror copy of the data can be access from a site that can be far away from the primary site. This feature ensures that cloud consumer's data cannot be lost and it is also available to the authorized user.

3.7.3 Google App Engine

The Google was bit late on the scene and by 2008, the Google App Engine was introduced to host the web application using multiple data centre (Google App Engine, 2011 and 2015). The platform is still considered as limited because the model has language restrictions. In the PaaS model only it can provide support to Python and Java so other languages cannot be supported. Also the model can process limited number of application which is drawback and restrict the users.

3.7.4 MapReduce

Google made major development in the MapReduce model as it can assist distributed computing using numerous clusters. The model is suitable for programming and development purposes. The model work effectively with the large bulk of data and it is considered as a

preferable option for big data analytics. The model has a self-built ability to recover from any failure and ensure data is stored at redundant site for recovery (Manyika et al, 2016). The model is preferred option for a complex research which is process intense and requires a lot of storage ability. Hadoop produced a model which is open source freeware available to be used by anyone.

3.7.5 Dryad

Microsoft produced the Dyrad framework that offers a declarative programing model that enabled the developers to effective use hundreds of thousands machines to perform concurrent programming. The model is effective and continuously support distributed computation and performs parallelization automatically.

3.8 The Cloud Computing Adoption Challenges

The following section will provide a detail discussion about the challenges and problems that are faced during the adoption of cloud computing option. These challenges are faced by the individual end users and all the organization regardless of their size while moving towards the cloud computing technology. For the ease of the reader these challenges are divided into technical barriers, institutional barriers and environment barriers.

3.8.1 Technical Barriers

3.8.1.1 Internet Connectivity

For the end user, the Internet's unreliability is a major technical problem that is not allowing individuals and enterprise from moving towards the cloud computing technology. In order to use the cloud technology most organizations will deploy Internet for cloud access. The problem is that the connection is working on the "best effort" model that can be problematic for some applications. The move towards the cloud computing technology will decentralizes your network and multiple vendors are involved so it becomes really difficult to manage all this operation where various different technologies having to work with each other for smooth operations. It is the responsibility of the end user and the enterprises to manage their own network, provide Internet connectivity from their end, ensure proper configuration of different devices such as firewalls, routers, switches, servers, PCs, smartphones, wireless

access point and all other devices that will be connected to the cloud technology. Cloud provider is restricted to help you manage and configure you network as that is the responsibility of the end user (Katz, Goldstein and Yanosky, 2010). The cloud provider can assist only to support the host specific programs that are being hosted by the provider but managing the network including the Internet connection is the primary responsibility of the end users. If the Internet is not operational and there are various technologies, applications, devices from various vendors that have to work together to ensure the connectivity, the end user will not be able to connect to the cloud technology and this is major technical barrier in the adoption of cloud technology.

The author further explains that there are organization and end users who think that just have the normal SSL or IPsec security is not a comprehensive solution and they desire to move to a solution that is more secure than the existing arrangement such as public cloud access. For these organization security is very critical due to the nature of the data but the barrier is whether the cloud provider is ready to provide a secure solution that the end user want to adopt. There are various non Internet connectivity option such as leased lines and virtual circuit service, virtual private network (VPN) based on MPLS and BGP and VLANs but these options are not universal standards which can be barrier in the adoption of the cloud computing technology. The special network connection will add more complexity and the cost for the end user as the network devices required for connection belong to an organization and complicates the relationship between the cloud provider and users in terms of resource allocation, support mechanism, problem isolation; and if there is a major outage for the cloud provider they have to reconfigure everything the chances are they will forget the special arrangement for these organizations.

3.8.1.2 Bandwidth Bottleneck

The bandwidth bottleneck is another major barrier in the adoption of cloud computing technology. For the end user the quick storage and retrieval of data using cloud is one of the major requirements. The bandwidth will be in the major demand as it will be shared among various end users to perform all these operations without any delay. For various enterprises accessing data quickly is very crucial to maintain the competitive advantage over their competitors. As correctly stated by Tom Conophy, CIO of InterContinental Hotel Groups (IHG),www.cio.com,*"If your employees and your users cannot access data fast enough, then*

the cloud will be nothing but a pipe dream". This statement is completely agreeable where various organizations are processing a large bulk of data and that information has to be passed and retrieved very quickly for example in the healthcare facilities where the life of patients depends on how quick the diagnostic takes place.

The bandwidth bottleneck is a major hurdle in the adoption of cloud computing technology. The users are familiar with the fast speed and quality of LAN, will not accept if there is delay in storage or processing of data or there is a poor quality of standards using cloud computing technology. The applications that are designed nowadays are interdependent with each other so they work by communicating with each other. So if these applications are hosted over the cloud platform between various data centres then there can be slowdown even no service while storing and backup of data (Amazon Web Services, 2014). Some of the application that are designed are not cloud-hardened as the programming code does not reduce the 'back-and-forth' communication between various machines this can breakdown or massively consume the bandwidth resulting in the bottleneck (Manvi and Shyam, 2015). This slowdown can be experienced by the end users who have just recently moved from the local area network to the cloud based due to the miscalculation of the requirements and real world performance of the system which is now resulting in the delay and bandwidth bottleneck situation. The bandwidth requirement increases if the application is intensive and complex processes are designed to perform a function. For these businesses they will require more bandwidth to accommodate these intensive applications. Also these factors can create a bandwidth bottleneck and have to be considered before shifting towards cloud based technology.

3.8.1.3 Big Data Analytics with Cloud Computing Benefits and Challenges

In the past the data that was generated used to be recorded and was reported to show the performance of the business. In the future this large amount of data that we are collecting will be analysed to make the business decisions. Nowadays we are creating nearly 2.5 quintillion bytes of data every day, and the figure shows that in last two years with social networking boom we have created nearly 90% of the total world's data (Manyika, 2016). The author further explains that according to Mckinsey Business Consultants, UK, the Big Data is a huge data set that is collection of structure and unstructured data so big in the size that the traditional database management tools cannot cope with this enormous data set. New approach and technologies are required to manage such diverse data sets. The Big Data should provide an intelligent solution to the business problem by generating an added value

economically from a large data set by exceeding the processing capability of the traditional database (Wang and Xing, 2011). The author further explains that Big Data is of a huge size which is unstructured so the traditional database management system cannot manage this type of data. The speed of the data is very quick and the nature of the data is imperfect and complex as it is located from various non-traditional access points. The need of the hour is to have a process that can convert this type of data into a perfect knowledgeable data that can allow the management to make decisions.

In order to perform this (Luo et al, 2016), the requirement is to use advanced computation machine learning languages that can make relationships within various entities of the dataset and highlight the key information that can allow the management to make strategic decisions. According to the authors the Big Data is a key force to promote innovation, productivity and growth across all the sectors and the technologies is dependent on the disruptive technologies such as Cloud Computing. The business consultancy, like The Mckinsey Global Institute (2015), provided a detailed estimation for the growth of the data. According to the report the volume of data is growing 40% every annum and till 2020 it will grow by 44 times. All this data is unstructured as we are gathering data from various sources such as sensors, social media sites, CCTV videos, mobile data, purchase transaction and many other sources. We need a technology that can manage, store, analyse and provide precise answer to the unknown areas. The Figure 3.8 shows that we are gathering data from different sources and need a tool to analyse, examine and process the data in such manner that the management can be make informed decisions based on this data.

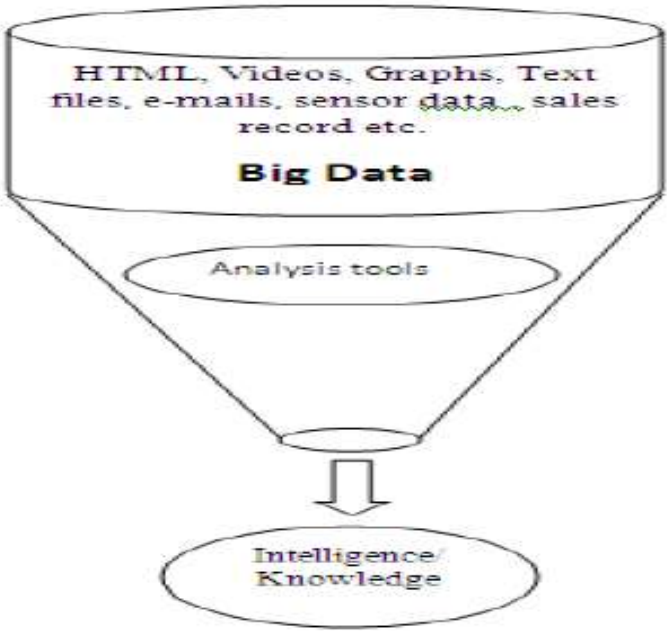


Figure 3.8 Big Data moving towards to Intelligent Data (Manyika, 2016)

With the use of big data the managers are able to make decisions in real time. This is only possible due the latest development in the field of information technology where powerful computing has arrived to the scene. Also the advanced database tools are available and the end user is mobile while connected to the Internet generating large amount of data on the social networking platforms. It is now possible to process this large bulk of data to make intelligent decision that can bring improvement in all sectors (Yang, Shanmugasundaram and Yerneni, 2016). In the big data we have to explore repeatable pattern in the data to identify the relationships (Marcos and Assunçãoaet, 2014). There are different categories of the data which are analysed in the process. The structure data is mostly available in the traditional database which follow set principle whereas unstructured data is completely raw data that has been collected from various applications over the Internet. Big data also contains semi structured data that is the combination of structured and unstructured data that is collected from the social networking websites (Agrawal, El Abbadi and Das, 2015). Big data contains dimensions about data such as data volume, data variety, veracity and velocity as shown from the Figure 3.9.

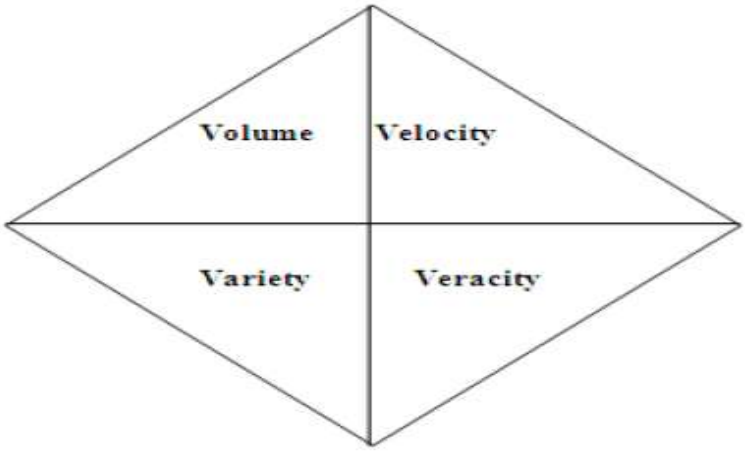


Figure 3.9 The Big Data Dimensions (Manyika, 2016)

- **Volume:** In Big data it is refer to the bulk of data collected from different sources. More data will can provide us with the opportunity to find relationship between each different entities that are hidden.
- **Variety:** In the pool of data there is collection from structure and unstructured data which has been collected from various sources so that it can be processed e.g. text data, sensor, video, audio files and log files.
- **Veracity:** Ensure to build trust on the data that has been processed so that the management can make their informed decisions. As the information is collected from various sources it needs to be verified and checked so that all stakeholders can have trust on the quality of the information collected.
- **Velocity:** For the big data the processing of data has to be very fast so that decision can be made in real time without any delay.

In order to process big data, it is very expensive and require a large amount of investment in-terms of money, manpower, time and effort. According to (Baraglia, Lucchese and De Francisci, 2015), there are more than 75% of Fortune 500 multi-national companies that have implemented the cloud based solution to process big data. Cloud provides the opportunity to process, store and analyse this data and help to manage data which is structured and unstructured as shown from the Figure 3.10. Many organizations are using Hadoop clusters on the cloud computing infrastructure which are very elastic and scalable in various environments such as Infrastructure-as-a-Service (IaaS). Various providers such as Rackspace is offering these deployments which offers low cost and reliable solutions to the end users.

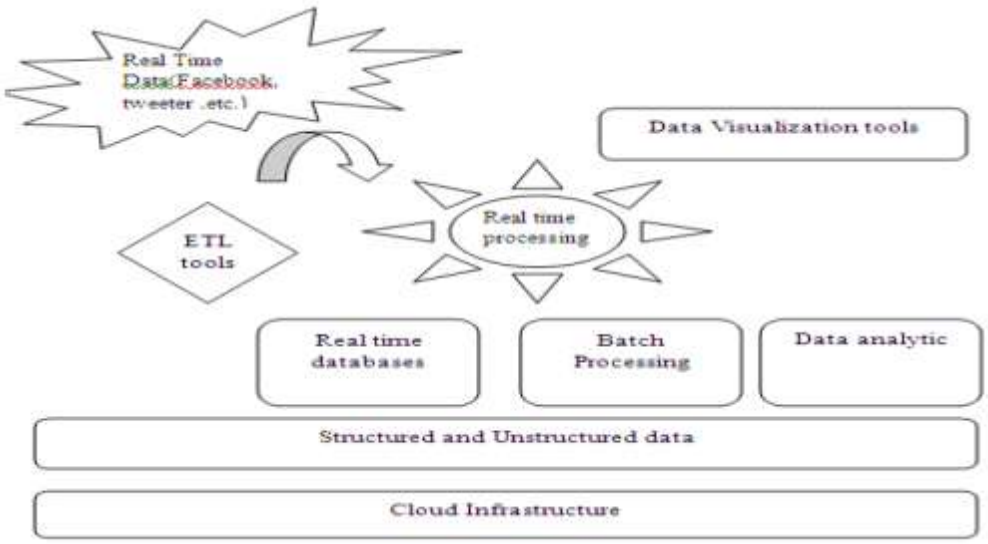


Figure 3.10 Big data with Cloud Computing Infrastructure (Manyika, 2016)

3.8.1.3.1 Benefits and Challenges of using Big Data with Cloud Computing

There are numbers of benefits with some serious challenges of using cloud computing to process big data. In the following section the study will identify some key benefits followed by the serious challenges of using Big data with Cloud Computing technology.

Reduce Cost: In order to process a huge amount of data the organization needs to invest a lot of money in the data centre to process all this data. Using the cloud computing technology there is no upfront capital investment required and there is a massive saving for operational and maintenance budget.

Flexibility: Using cloud computing will provision new resources so that fast moving data can be processed quickly so that real time decision can be made.

Improved Automation: Big data required a large amount of resources to process the data. Due to the nature of the job sometimes the underlying resources requirements changes automatically. Cloud computing is fully equipped to automatically provision more resources when the demand is high followed by de-provision when the demand is less. This will increase the utilization of resources.

Sustainability: As big data requires a large amount of processing power resulting in a high energy consumption. The traditional data centres are not energy efficient. So it is evident that this traditional model with big data analysis is not economically or environmental sustainable. Using the cloud computing infrastructure will save a lot of energy and cost.

3.8.1.3.2 Challenges of Big Data using Cloud Computing

In the following section, the study will discuss various challenges and problem of Big Data analyses using Cloud Computing infrastructure.

3.8.1.3.3 Scalability Challenge in Big Data using Cloud Computing

Scalability provides a unique quality to store and process the data that is increasing and continuously multiplying every day (Leavitt, 2013). Cloud computing is not able to support the RDBMS. The author further explains that RDBMS is not suitable for implementation at a large scale in the cloud computing infrastructure. Due to this weakness NoSQL database are gaining popularity as they support storage and processing for large bulk of data.

3.8.1.3.4 Availability Challenge in Big data using Cloud Computing

The users are storing a large amount of data over the Internet. Availability demands that required resources are provisioned based on the demand of the users. The challenge is related to the availability of the important data that is stored using cloud computing infrastructure (Assunção et al, 2013). The end users are using social network websites and they are storing large bulk of data over the Internet. These users are becoming more mobile and want to access and process this data while they are on the move. There is a major problem for cloud users to access this data. As mentioned by (Lee et al, 2016) it is crucial for cloud provider to make this data available for the cloud users. Data availability will continue to challenge the cloud provider as the demand of real time access to the important data is the most important requirements of the businesses which needs to be addressed. The availability of data will continue to be an issue as the technologies are changing and the end user us using smart phones to access data while moving from one place to another (Mell and Grance, 2011).

3.8.1.3.5 Transformation Challenge in Big data using Cloud Computing

In big data analytics the transformation of unstructured data to sensible or structure data is a major obstacle. As the data will be collected from different sources and will be in different formats so transforming that raw data to a meaningful data is a huge obstacle. As (Wang et al, 2011) explains, that unstructured data has no meaning and to transform that data to a meaningful data needs a detailed transformational process which is a major obstacle. Initially this unstructured data have to be stored in the distributed database that can HBase. Then this

unstructured data will be extracted from the database. In order to structure the data it has to go through the pre-processed stage before it is stored in the relation database to incorporate the scheme-on-write issues (Zaerens and Mannonen, 2012).

3.8.1.3.6 Heterogeneity Challenge in Big Data using Cloud Computing

In big data analytics data is collected from various sources that lead to the heterogeneous collection of big data. The data which is of different types and origins possessed incompatible format and problems with its presentation (Zaerens and Mannonen, 2012). The challenge is how to manage the structure, semi-structure and unstructured data format. It is problematic to present the unstructured data in the form of rows, columns and tuples.

3.8.1.3.7 Privacy Challenge in Big data using Cloud Computing

Privacy is major challenge that is affecting users who have transferred large volume of data over the cloud (Baraglia, Lucchese, and De Franciscic, 2015) and (Leavitt, 2013). There are serious concerns about big data mining that can be exploited or can be stolen which will compromises the confidentiality and data privacy.

3.8.1.3.8 Governance Challenge in Big Data using Cloud Computing

Data governance and management of data is a challenge for big data using cloud computing technology. The major problem for big data is cloud governance and management to the applications that have generated a large of data from various external sources and how to manage this bulk data. In order to provide a proper data governance and address this challenge the needs to design a detailed acceptable data policy which explains what type of data can be stored and how the end user can retrieve that data. Where should be the cloud provider based to host this large amount of data? All this needs to be explained in the policies so that this obstacle can removed.

3.8.1.4 Data Protection and Privacy Challenges in Cloud Computing

Data protection and the privacy of the data is the other challenge while the business decide to move towards the cloud computing infrastructure. There are various concerns raised by the stakeholders that the most important asset of any business is their data will be stored outside the traditional data centre with a minimal control and management mechanism. In terms of

data protection and privacy the concerns are further exaggerate as the cloud computing model provides a distributed infrastructure where the provider can be based across different parts of the world where data protection and privacy laws are very relax as compared to the European Union (EU Commission, Data Protection Report, 2012). These challenges are really a matter of a concern; as there is an introduction of a new framework after detailed discussion for EU data protection framework known as 'The General Data Protection Regulation' (GDPR). According to Andrus Ansip, Vice President for the Digital Single Market, European Commission, this new law will lead to "digital single market", which will provide a framework for all EU member states without any need to implement the national legislation. The law will come in force in 2018, but it will have serious financial implication for the business if they fail to protect the privacy of the data. That is the reason Nigel Parker – Partner, Allen and Overy stated that a large amount of cloud providers and cloud users have to re-evaluate their functions and processes now so that they abide by the new framework which will have a far reaching impact. According to the new framework if there is a data breach then there can be fine up to the 4% of the worldwide turnover and EUR 20 million if the breach has taken place related to international transfer or the condition for consent is not met. The law for other breaches impose fines of up to 2% annual worldwide turnover and EUR 10 million. To impose these various fines will be based on the nature, scope and duration of the breach. Due to data protection and privacy it will be challenge to move toward the cloud computing solution. The industry needs to address the upcoming changes in terms of General Data Protection Regulation' (GDPR) so that these challenges can be addressed effectively.

3.8.1.5 Reliability and Availability issues in Cloud Computing

To move towards a cloud technology there are serious challenges in terms of reliability and availability of data. Cloud infrastructure is distributed with multi-tenancy which is considered as a major reason for various threats. Due to resources sharing nature of the technology with the virtualization it comes under cross site scripting or attacks at the virtual machine level resulting in affecting the reliability of the data and raising availability concerns. There are concerns due to badly designed and configured APIs that can lead to DDOS (Distributed denial of service) attacks and all the services and data will not be available to the authorized users (Bello and Russo, 2016). Cloud providers need to provide a service 24/7 as there are multiple examples of outages of services. According to authors, the outages are happening at

far higher rate than promised by the cloud provider. According to the data collected there were 56 instances of outages with Amazon Web Services and these outages affected across the four key services such as virtual compute, storage, content delivery network and domain name service with a total downtime was more than 2 hours and 30 minutes. But in other cases the situation is even worst as Microsoft Azure and Google Cloud Platform had experienced more than 5 times the downtime with Azure having 71 outages of nearly 11 hours and Google Cloud had 167 outages with nearly 11 hours and 34 minutes without the service. IBM was the worst performer with outages nearly for 17 hours that was recorded by Cloud Harmony in 2015 as shown from the following Figure 3.11.

Figure 3.11 Cloud Downtime in 2015 (Cloud Harmony, 2015)

So availability and reliability is major issue while opting for cloud service and this needs to be addressed before more users opt for the cloud technology.

3.8.1.6 Interoperability and Portability issues

When businesses store their data on the cloud provider they should have the freedom to move their data from one provider to another. The cloud users should have the autonomy to migrate their data from one provider to another and there should not be any restrictions or lock in requirements set by any party involved. According to the Cloud Standards Customer Council, 2014, there are many challenges related to interoperability and portability while using cloud computing technology. The report identifies the reason of weak interoperability and portability which are lack of uniform standards by providers and they have implemented different APIs which are different for each provider resulting in interoperability problems. The report further explains that at IaaS (Infrastructure as a Service) offers an effective

interoperability whereas in PaaS (Platform as a Service) the standards are very weak without following a uniform standard across various providers. For SaaS (Software as a Service) the challenge of interoperability and portability is severe and it creates massive problem for the cloud users. There is a limited standards APIs for SaaS application and moving data from one provider to another provider is a major challenge for the cloud users as there is major interoperability and portability issues according to the report.

3.8.1.7 Infrastructure Security

In cloud computing there are concerns raised about the security at the infrastructure level. According to (Chandramouli and Mell, 2010), when developers are programming using the PaaS environment they will have no direct access to the underlying layer. As the developers and programmers have no access to the data centre level then they cannot secure it and security of the infrastructure is left to various providers. The author explains that when the programmers are responsible for the security of their programs they are not sure that the environment is which they are working is secure. Both SaaS and PaaS are multi-tenant as number of users will be utilizing these resources at the same time which can be security concern. The authors further explain that the IaaS is also a multi-tenant environment and data from large amount of users are stored together which is a security concern. It requires proper data segregation but that is not controlled by the cloud users as it is the responsibility of the cloud provider. As the cloud provider infrastructure cannot be access by the users the security at the site is a major concern for various cloud users.

3.8.1.8 Data Security

For the cloud environment one of the most serious challenge is the security of the data over the cloud computing infrastructure. According to the, InfoWorld,www.csoonline.com “The Dirty Dozen: 12 Cloud Security Threats”, 2016 as the cloud provider is storing data from various users, it is a prime target for hackers. The data security breach by exposing the personal information or stealing the banking details or trade secrets will damage the reputation of the organization permanently. According to the article published in the InfoWorld, data security breaches can take various shapes and forms. Data security breach can also take place due to weak authentication procedures such as lack of password policy or

due to not managing the keys or certificate management. Data security breaches can take place due to identity management and fixing the correct permission to the right job role. The data security can be breached if the employee user access is not maintained properly. An employee working for one department moved to another department and they still can access files from the previous department or an employee who left the organization still can access the data. These issues will lead to data security breaches which can affect the entire operation. The cloud services are using the APIs to manage and interact with all cloud computing resources such as cloud resource management, monitoring of all resources and scalability functions. Data security, its confidentiality, integrity and availability depends on the security of the APIs. According to the CSA (Cloud Security Alliance, 2014), poor interface design and weak APIs will lead to the security breach in the cloud computing environment. In order to improve security and avoid any data breaches the APIs security should be updated and uniform standard should be followed across various cloud providers.

As cloud computing infrastructure is a multi-tenant model where all resources are shared between different cloud users. By adopting various practices such as performing vulnerability scanning, regular patch management and updating all the software's will ensure all vulnerabilities are removed from the system. The CSA recommends that the cost of mitigating system is the best solution as compared to the repairing the damage which will be very expensive for the business. The data security breach can take place due to phishing and software exploit in the cloud computing services. The hacker can deploy a Man-in-the-Middle attack (MITM) or eavesdrop on the activities so that they can collect information which can allow them to manipulate transactions and modify the data in an unauthorized manner. Attacks can come within the network in the form of insider attacker. The malicious insiders can illegal export data out of the organization or completely destroy the whole infrastructure. Various other ways where the data security can be breached are the abuse of cloud service such as using the cloud computing very high resources to you a brute force attack to break the key or using DDOS (Distributed Denial of Service Attack) to flood the servers with so much of traffic that the data and services are not available. So data security is major concern for users opting to shift towards the cloud computing technology.

3.8.1.9 Moving Infrastructure to Cloud Computing

The economies of scale will benefit the cloud computing model as compared to the traditional data centre. This concepts of economies of scale shows the production cost will go down as we produce more and more units. If we apply this rule to the cloud computing according to John Moore, O'Reilly Media, an organization would need to deploy around 5000 and 15000 servers to achieve 'per-sever' marginal cost at the same level that is experienced by cloud computing. In the same report there was comparison of the cost between the internal IT data centre as compared to the cloud provider. According to the following Table 1 that was presented in the report clearly states that there is a massive saving in the cloud computing infrastructure as compared to the Internal IT data centre.

	Internal IT	Managed Services	The Cloud
Capital Investment	$40000	$0	$0
Setup Costs	$10000	$5000	$1000
Monthly Services	$0	$4000	$2400
Monthly Labor	$3200	$0	$1000
Cost over Three Years	$149000	$129000	$106000
Savings gained	0%	13%	29%

Table 1. Cost comparison between Internet IT and Cloud Computing (O'Reilly Media,2009)

3.8.2 Institution Barriers

3.8.2.1 Lack of Understanding

According to (Golden, 2014) at CIO.com, "Has Cloud Computing been a Failed Revolution?" one of the participants explained with data from the Google search engine with the term "cloud computing" is showing a downwards trend. Now the question is whether the general public including the IT Staff are not interested in the technology or there is lack of public understanding about the technology as shown from the Google search data shown in the Figure 3.12.

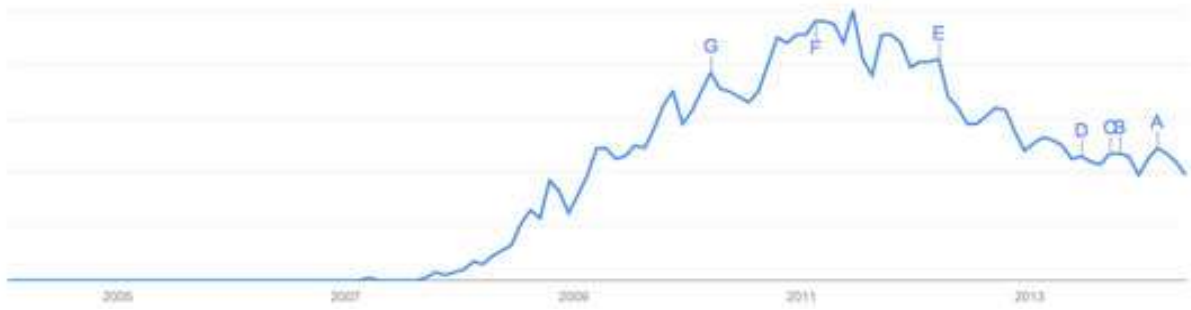


Figure 3.12 Google Search data "Cloud Computing" Highest in 2011 and showing downward Trend

(CIO from IDG, 2014)

The participants in the conference discuss the reason and it was evident that there is lack of public understanding about the technology. Including some of the technical staff not familiar with the technology which is the reason there is a downward trend. The participants agreed that most of the organization have started the move towards the cloud computing and very few are able to complete the entire shift. The general public awareness and extra training for the technical staff is required to address any concerns about the technology and to increase the awareness about this technology.

The cloud computing technology has a totally different meaning to an audience where the requirements are different from each other. For the senior management the cloud will reduce the cost of the operations. For some audience it will improve the effectiveness of the operation and allow them to have consistent approach to reduce the gap in the IT systems. For a group of audience, the cloud computing will open new venues for the business. There is an audience which will not support this new change as their job is at risk or needs more training or they feel the operations are more secure in the traditional layout. So various people will see cloud technology from their own perspective which will affect the level of commitment about the technology.

3.8.2.2 Management Commitment

The commitment from the senior management is the key to adoption challenge to the use of cloud computing. The management have to ensure that the technology helps to meet the strategic interest and goals of the organization. The main benefit of using cloud technology is the ease of managing all functions centrally and coordinate all the actions that are required to

meet the business objectives (Jay, 2014). Whereas in the same organization there will be departments or managers who will not be interested in this large scale change which can affect the whole operations. The senior management commitment with the influence is required for the complete deployment and use of cloud technology.

3.8.2.3 Organizational Readiness

The cloud deployment requires that the particular organization is ready for the implementation of the cloud technology. The lack of organizational readiness is a major problem in the adoption of the technology. Before the actual cloud deployment is initiated there are list of few key services should already be in place. In order to ensure that the organization is ready for cloud migration it requires the complete institutional realignment in terms of strategic objectives and the goals they would like to achieve. The staff and administration needs to be trained with the technical details of the technology and the benefits associated with this new model. The senior management and all stakeholders should go through the training and awareness program so they become a stakeholder in the smooth implemented of the cloud technology and ready for this move (Anjali and Pandey, 2014). Concerns with the implementation of the new technology will drastically affect the working of the staff or there will be a major downsizing in the staff numbers should be addressed to ensure that the organization is ready for the implementation of cloud computing technology. In order to evaluate the readiness of the organization to opt for the cloud computing technology it is essential to measure the value and the cost of implementing the new technology. Then all hurdles should be analysed while moving towards the technology. Finally, what will be the overall impact of integrating this technology into the organization needs to be evaluated. These issues are very critical and can be a major obstacle in the readiness of the organization for the deployment of cloud computing technology.

3.8.2.4 Governance and Management Structures

All sector whether they are in the public or private sector will face various challenges in-terms of governance and management while adopting for cloud computing. Before we move towards the cloud option the business needs detail set of assurance that will integrate legal aspects and follow all the set standards and procedures. As the cloud model is disperse across the geographical divide the governance and management of cloud computing resources,

process and procedures is a very difficult task. The management and governance of cloud computing becomes really difficult if the data is hosted in the part of the world where the laws are totally different then the home origin of the data. The cloud technology has a complex process because there are various stakeholders involved and all of them have to communicate with each other before the adoption of the technology. The Governance and Management system is required to set procedures how the communication between various stakeholders will take place. The mechanism will set the basic rules of operations and define steps that have to be followed before any final decision is made. The weak or non-existence of these governance and management system is considered as a major barrier to the adoption of the cloud computing technology.

3.8.2.5 Migration of Applications a Challenge

Businesses are planning to adopt the cloud computing technology due to its enormous benefits. The cloud computing model and its technology is under structural transformation as the user requirements are changing. To fully take advantage of the technology all services including the legacy applications needs to be migrated to the cloud computing. According to (Holland, 2016), migrating these legacy applications to cloud is a major challenge. The author further explains that to migrate these legacy application a significant work is required to make low level changes so that these applications are portable to the new cloud computing platform. Due to less agility it will take more time to introduce new application or these services to the market as these applications need to be redesigned so they are compatible with the new environment. This effort of maintaining all the legacy application will be very expensive over the years for the businesses to manage. In some cases, these legacy application are difficult to integrate with the newer standards and cannot be used at all resulting in a major loss for these organizations. The legacy application migration to cloud computing can be a huge challenge and considered as a barrier to the adoption of the cloud technology (D'Agostino et al, 2011).

3.8.2.6 Skills and Personnel Training

For the smooth transition to cloud computing technology; the technical and non-technical staff needs an extensive training to use the technology. According to Forbes, www,forbes.com in 2014, a detailed survey of more than 1000 IT professionals and network managers was conducted by the Science Logic. According to the survey results more than

50% of IT staff responded by stating that they need more IT training to meet the job requirements and ensure the smooth running of cloud computing technology. The same situation is true for non-technical staff who will require training on the use of cloud computing technology.

Lack of skills in the field of cloud computing technology is a major challenge in the successful adoption of the cloud computing technology. Accenture conducted a survey for more than 286 federal managers working for U.S Federal agencies and only 10% of these agencies were able to move towards the cloud computing technology. The problem that was highlighted in the survey was due to lack of skills in the field of cloud computing technology there are having problems to ensure the smooth transition. Also the survey gave a further insight by stating that nearly more than two third of the respondents don't have staff with the skills to execute the cloud strategy. Also about 45% of respondents wanted a new training and skills development drive to train more staff in the cloud technology so that more business can easily move towards the cloud computing technology. Until this is not done the transition from the traditional model to the cloud model will face major barriers.

3.8.2.7 Departmental Downsizing

There are concern about the departmental downsizing due to the use of cloud computing technology. These concerns have to be addressed and staff should be ensured that with proper training and more skills staff will be working for the organization. For the major cost saving the organization can expand their operations by hiring more staff. In some organization the concern about the downsizing of the staff is an obstacle towards the move towards the cloud computing which need to be tackled to address this concern.

3.8.3 Environmental Barriers

3.8.3.1 Service Level Agreement

The next major obstacle in the adoption of the cloud computing technology is the lack of uniform service level agreement. There are many cloud providers in the market and they provide different SLAs for the same services which can be very confusing for the potential cloud users (Li et al, 2017). This is a major barrier in the adoption of the cloud computing.

The cloud computing technology has enormous benefits but there are serious concerns and challenges related to different or lack of uniform standards of service or nonexistence of minimum benchmark for level of services across the industry to provide an effective, uniform and reliable service to the cloud users. As the cloud computing is gaining popularity organizations and users are having problems to adopt the service due to lack of minimum service level framework which can act as a benchmark in the selection of the cloud provider and provide quality of services according to the users' expectations. The situation becomes more critical due to distributed nature of the service provider which can be offering service from any part of the world. Due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the industry there are serious concerns raised recently in security and data privacy breaches, authentication and authorization, lack of third party audit and identity management, integrity and variable availability standards, confidentiality and no uniform incident response and monitoring standards.

Due to the design of the model the client or customers has lack of or no control over their data and where Internet is used as a communication media to access data (Taha et al, 2014). The security and privacy of the data in the cloud computing is a major issue and the provider has to provide concrete assurance in Service Level Agreement (SLA) to assure the customer regarding the data protection and privacy issues (Burkon and Lukas, 2013). The increase of public cloud providers, cloud consumers face various challenges such as data security and privacy issues, authorization and authentication breaches, poor availability standards, lack of interoperability and response time standards, methodology to allocate resources, weak or no third party audit mechanism and lack of monitoring and responses standards (Baranwal and Vidyarthi, 2016). There is different Service Level agreement from different providers for the services which confuses the cloud users and it is considered as a major obstacle in the adoption of the cloud computing technology.

3.8.3.2 Compliance and Auditability

The cloud computing technology still is debating on a mechanism for compliance and uniform approach to conduct a third party audit that is agreed by all the stakeholders and becomes a uniform standard across the cloud market. This mechanism is not available at the moment and due to this reason there is barrier for the users to starting using the cloud computing services. Until these barriers are resolved and a uniform approach is not agreed

that acts like a benchmark for compliance and detailed audit users will not feel comfortable moving from the traditional data centres to the cloud computing model.

3.8.3.3 Society, Cultural and Resistance to Change

The use of cloud computing technology will change the way we operate, store, access, analyse and share information between each other. The end user requirements are changing how they want to interact with the data. The adoption of the new technology will require to bring large amount of institutional changes, how we work, how we communicate with each other, issues on the privacy of data and who can access that private data. The adoption of new technology will surely impact the social and culture values and bring drastic changes in communities across the world which in some cases will not be acceptable to the traditional guardians of the society. The adoption of the new technology will have far reaching impact on all sections of the society and the force of change will push for new way to think and behave and new rules that will be challenging for certain sections of the society as mentioned by (Baker, 2015). The use of social media is a prime example where people from across the world can interconnect and share ideas with ease. Innovation and revolutions are starting over these platforms and the use of technology is removing all the barriers and making it possible. These fast change will make some sections of the society uncomfortable and they can create barriers in the adoption of these technologies which are a danger to the traditional way of thinking and having a massive impact on the social and cultural values. Some organizations just like individuals for their own benefits will resist the process of change and create hurdles in the adoption of new technology. When organizations, people or any community feels threaten due to the force of change they will create as many problems as possible so that new approach cannot be adopted. The same is true for cloud computing technology as it will bring changes to all sections of the society; the resistance to change and social and cultures traditional issues can be a hurdle to the adoption of the technology.

3.9 The Cloud Computing: Impact on Key Business Sectors

According to, The Economist: The Intelligence Unit (2016), https://www.eiu.com, cloud computing has taken the global business market by storm as more than 90% of multi-national companies are using cloud or thinking of moving towards the new model as a part of their strategic business alignment. The report further indicates that more than $33 billion was spend in the cloud industry in 2015. In the sponsored conference that was having 360 senior

executes, decision makers and C-Suite members. The entire audience was very optimistic in using the cloud computing technology and considered the future of cloud computing very bright and have already moved or in the process of shifting towards the cloud computing model. There is a large debate taking place across all the business sectors; in the adoption of the cloud computing technology. According to the conference there were various key observation that were made on the adoption of the cloud computing technology depending on the type of the industry. The first major observation that was indicated in the conference was that the adoption rate for businesses that generate digital information that goes hand in hand with the traditional industry is very high and they are ready to move towards cloud earlier than any other industry. Industries offering electronic banking that is changing from the traditional banking through various branches is the best example to opt for the cloud computing option. As the research data from various industries indicate that the current practice of cloud computing is on rise across various sectors. Business sectors such as banking and retail is experiencing the significance presence of cloud computing as compared to health and education sector due to various regulation according to the EU commission survey shown in the following Figure 3.13. The pervasive presence varies from sector to sector and on average it is 7% across all industries and facing a downwards trend as more businesses are using cloud services.

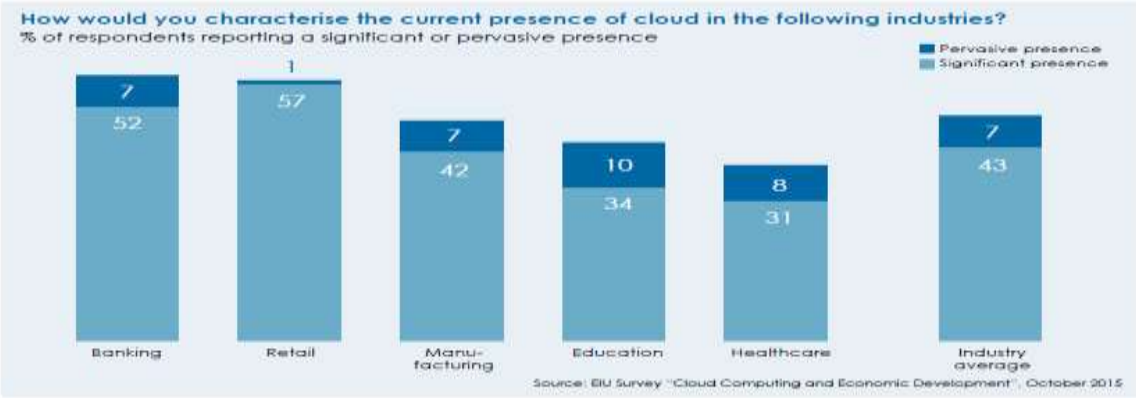


Figure 3.13 Industry Landscape: The presence of Cloud Computing ((EU Commission Survey, 2015)

3.9.1 The Cloud Computing: Banking Sectors and its Impact

The banking industry is using the cloud computing technology more than any other industry according to the data presented in the conference, The Economist: Intelligence Unit in 2015. The banking industry is using cloud computing to support their administrative back office

operation and the second way the technology is used to digitally compare various key banking products. The subpanel in the conference; nearly 80% agreed that cloud will become a part of the banking sector will plays vital role in order to meet the strategic objectives of the banking sector. Also there is a new trend that is emerging where cloud technologies are working together with the non-cloud computing technologies. This new shift where the cloud technology is working with the non-cloud computing is creating a large amount of concern in-terms of data security and privacy. According to the EU survey as shown from the following Figure 3.14, clearly indicates that cloud computing penetration into the banking industry is on high and all the participants agreed in the next 5 years cloud computing technology will be heavily used in the banking sector.

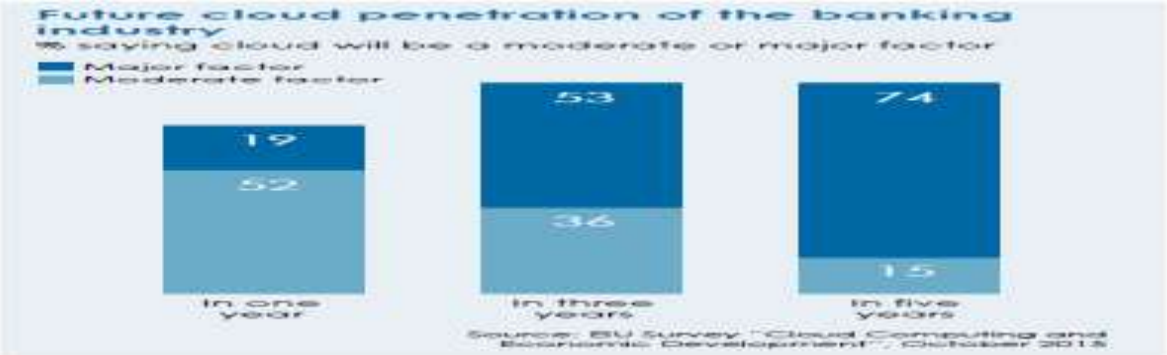


Figure 3.14 Cloud Penetration in the Banking Industry (EU Commission Survey, 2015)

In the survey it was very evident that all participants think that the use of cloud computing is very important for the banking industry. By using the technology industry can take major advantage by lowering the cost of banking, provide new ways for the customers to make payments and find new opportunities to reach the remote population that cannot access the traditional banking system. The survey results in the Figure 3.15 clearly indicates the importance of the cloud computing for the banking industry which can revolutionize the sector forever. According to the survey, 68% of respondents agreed that cloud computing provided new ways to make payments in the banking sector and 60% agreed that cloud technology helped to reduce the cost of operations in the banking sector. Also 57% agreed that cloud computing allowed banking services for remote population which was not possible before.

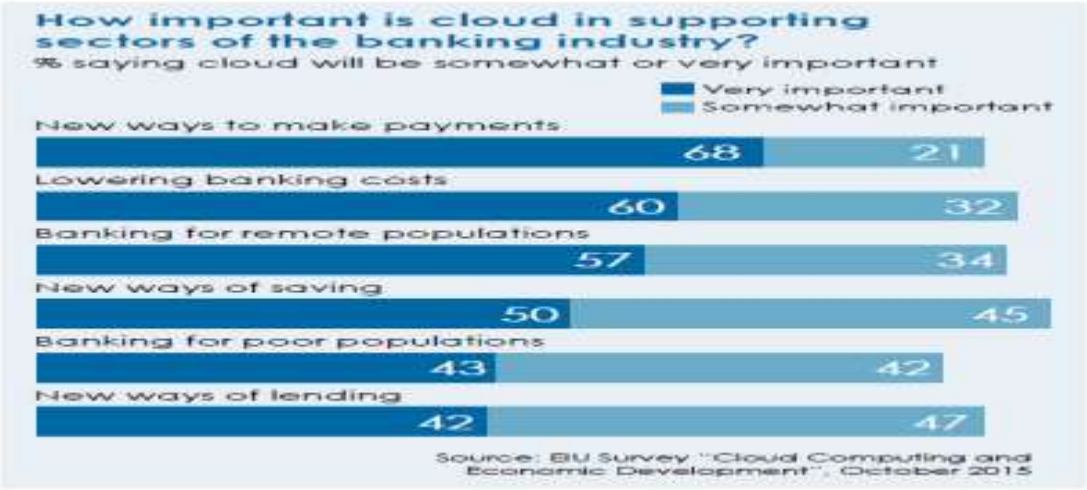


Figure 3.15 Importance of Cloud Computing for Banking Sector (EU Commission Survey, 2015)

3.9.2 The Cloud Computing: Retail Sectors and its Impact

According to EU survey, the retail industry is also experiencing a major shift where the penetration of cloud computing technology in the retail industry is facing an upwards trend. The data collected from the survey shows the use of cloud computing technology will increase by five-fold in the retail industry in the next 5 years. The survey results shown clearly from Figure 3.16, indicates that 70% of respondents agreed in next five years the cloud computing technology will be a major factor in the retail industry and play a vital role to meet the industry strategic targets.

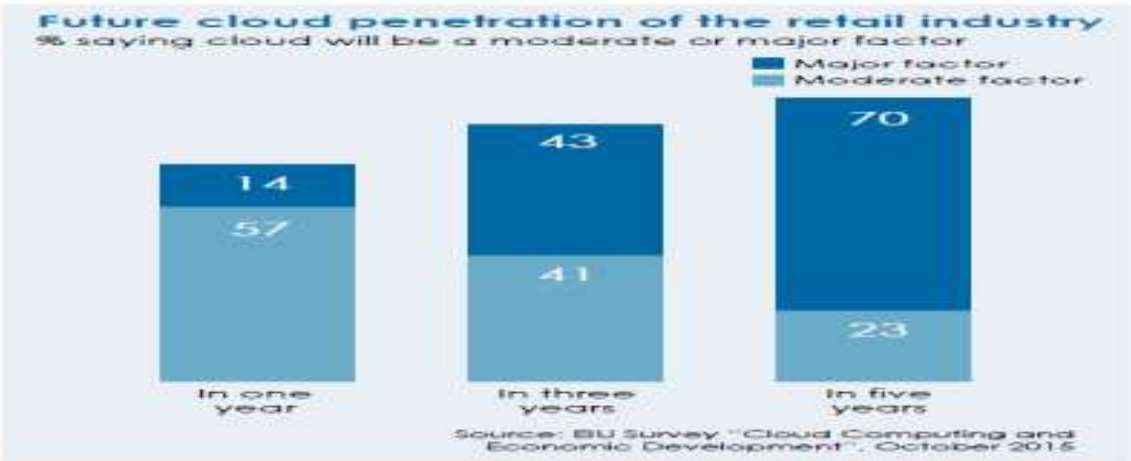


Figure 3.16 Cloud computing penetration in Retail Industry (EU Commission Survey, 2015)

The respondent gave a very positive outlook for using cloud technology in the retail industry. More than the majority of respondents agreed that the cloud computing technology will reduce the cost of operation and that will help to reduce the prices of various good and services. The retail industry agreed that the cloud computing technology will allow more business to open up as there is no capital investment required to buy expensive hardware and network infrastructure. The majority of respondent in the figure 3.17 in the survey agreed that by using the cloud computing technology the access to retail market will increase which in turn will bring more business for the industry by reducing the cost of good and service offered and helping new companies to grow. 58% of respondent agreed that cloud computing technology is very important to reduce the cost of good and services, 49% agreed that technology helps to grow new companies and 48% consider the technology very important in increasing the access to retail.

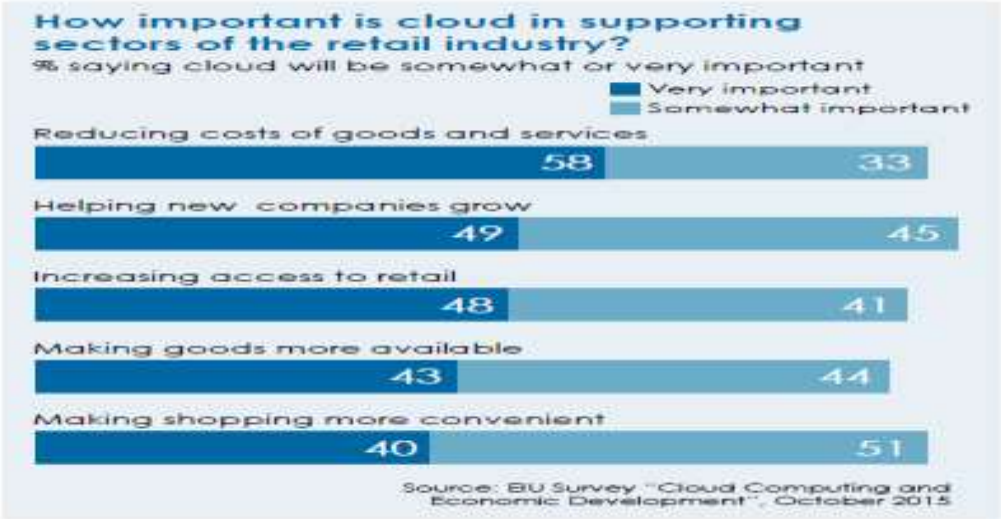


Figure 3.17 Importance of Cloud Computing for Retail Sector (EU Commission Survey, 2015)

3.9.3 The Cloud Computing: Manufacture Sectors and its Impact

The manufacture industry was bit slow to start using the cloud computing technology as compared to other industries as in the manufacturing the need is to integrate the technology into the hardware equipment. This can lead to technology implementation delay where we have to integrate GPS marker into an ordering of different parts. According to the EIU survey results presented in the Economist: The Intelligence Unit, 2015, showing a great interest by the manufacturing industry is using cloud computing to boost their manufacturing capabilities by improve the quality of products with improve efficiency and reduce cost. Also the technology can support the administrative back office operation and using big data analytics

to process large bulk of unstructured data to produce products according to the demand of the market. The participants in the sub-panel in the conference more than 70% agreed that cloud computing technology in the next 5 years, will become a major part of the manufacturing sector to meet the strategic objectives of the sector as seen from the following Figure 3.18. Also there is a new trend that is emerging where cloud technologies are working together with the non-cloud computing technologies in the manufacturing industry. The transition is taking place towards cloud technology but with the new shift where the cloud technology is working with the non-cloud computing is creating a large amount of concern in terms of data security and privacy.

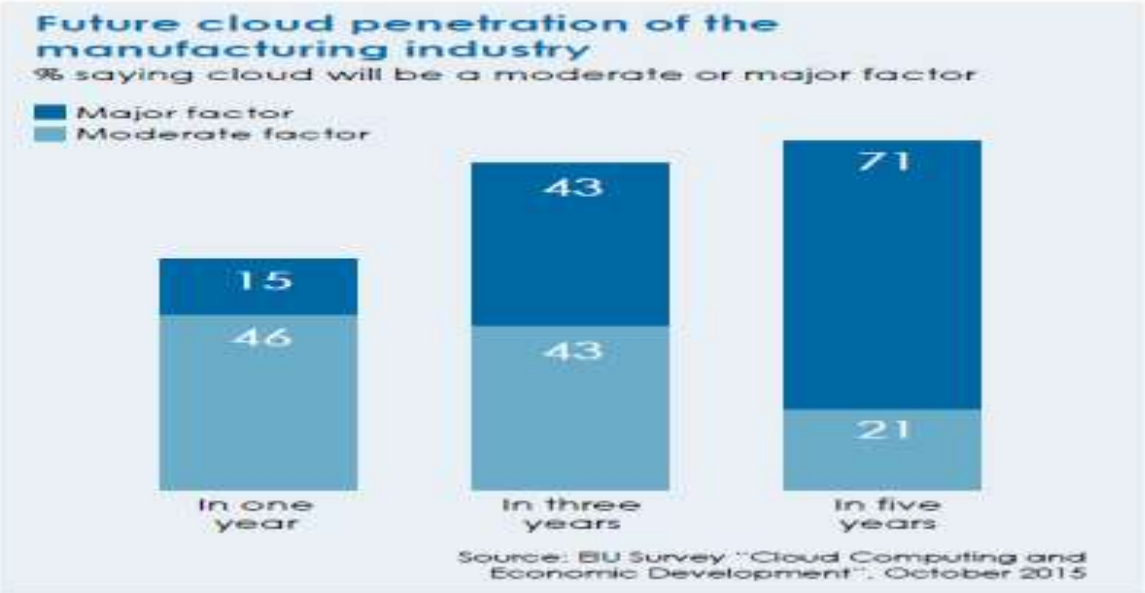


Figure 3.18 Cloud computing penetration in Manufacturing Industry (EU Commission Survey, 2015)

The respondent gave a very positive outlook for using cloud technology in the manufacturing industry. More than the majority of respondents agreed that the cloud computing technology will improve and support the production processes by increasing efficiency of the process and reducing the overall cost of the operation. The manufacturing industry also in the survey agreed that using the cloud computing technology will improve the supply chain management and reduce the waste that will results in improving the overall design process of the products. More manufacturing businesses will start their operations as there is a huge saving on the initial capital investment required to buy expensive hardware and network infrastructure. The majority of respondent (60%) in the survey agreed that by using the cloud computing technology in the manufacturing industry will support production processes, 54% consider cloud technology very important to improve the supply chain management and 52% agreed

with the importance of the technology to improve design and prototyping as shown in the survey results in Figure 3.19.

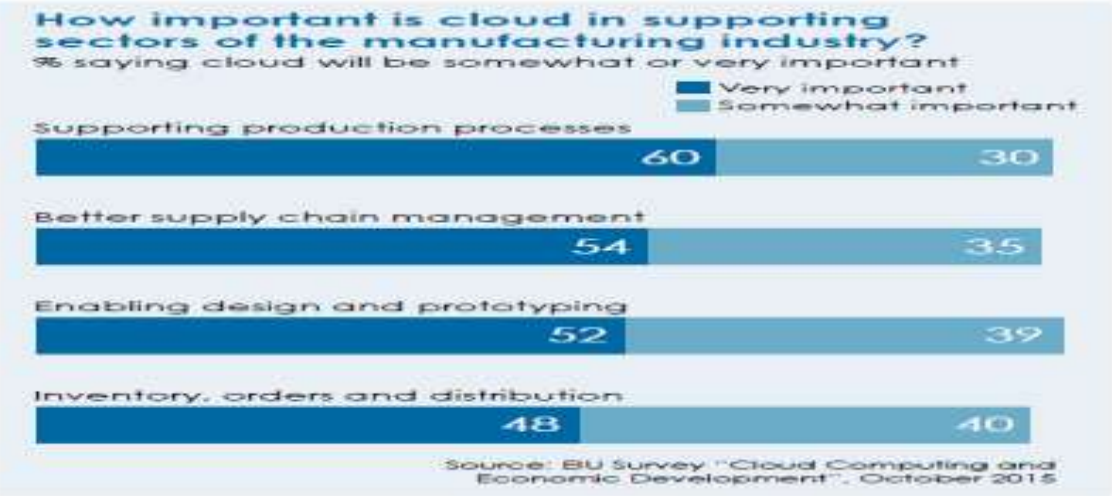


Figure 3.19 Importance of Cloud Computing for Manufacturing Sector (EU Commission Survey, 2015)

3.9.4 The Cloud Computing: Education Sectors and its Impact

The education industry was slow to start using the cloud computing technology as compared to other industries due to less competition, concerns about the security and privacy of confidential data and slow government adoption. It is evident the education is becoming more mobile and the way of gaining knowledge is under a massive change itself. Students are very mobile and want to learn on the move and the structure of traditional classroom is completely changing. The online education and open online courses are changing the way we learn. In the coming next couple of years this trend will require a technology to support the way we prefer learning. According to the EU survey results presented in the Economist: The Intelligence Unit, 2015, in the next one year the cloud computing technology will not have major influence in education but the trend will change in next 3-5 years when more people would like to enrol online then the cloud technology will have a major influence in the education industry. The participants in the sub-panel in the conference; around an overwhelming majority of 67% agreed that cloud computing technology in the next 5 years, will become a major part of the education sector to meet the strategic objectives of the sector as seen from the Figure 3.20. The use of cloud technology in education will allow more people to access education and reduce the overall cost of the operations.

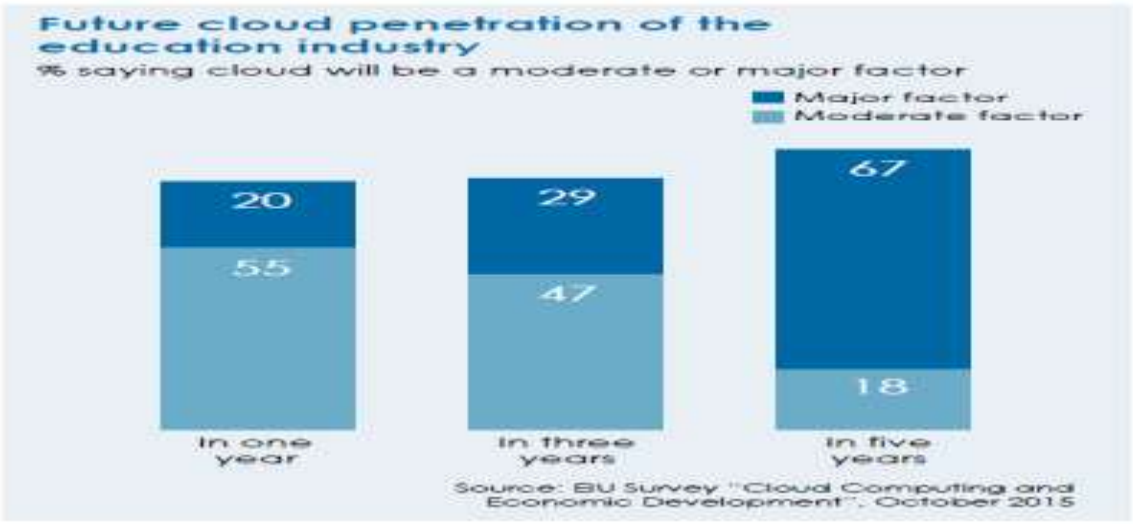


Figure 3.20 Cloud computing penetration in Education Industry (EU Commission Survey, 2015)

In the survey it was very evident that all participants think that the use of cloud computing is very important for the higher education institutions. It is very crucial that the higher education provides a secure and reliable technology so that students can remain connected to the higher education and continue with their studies while they are working. By using the cloud technology education can be spread across the remote areas where people can access education continue to update their skills so that they add value to the economy. Also the use of technology in the education will reduce the overall cost and allow people in different age group to equip themselves with these new skills from the comfort of their home or workplace. The survey results in the following Figure 3.21 clearly indicates the importance of the cloud computing for the education industry where 51% of respondents think cloud computing is very important for the education sector and 42% agreed that cloud technology can help to promote education in remote areas of the world.

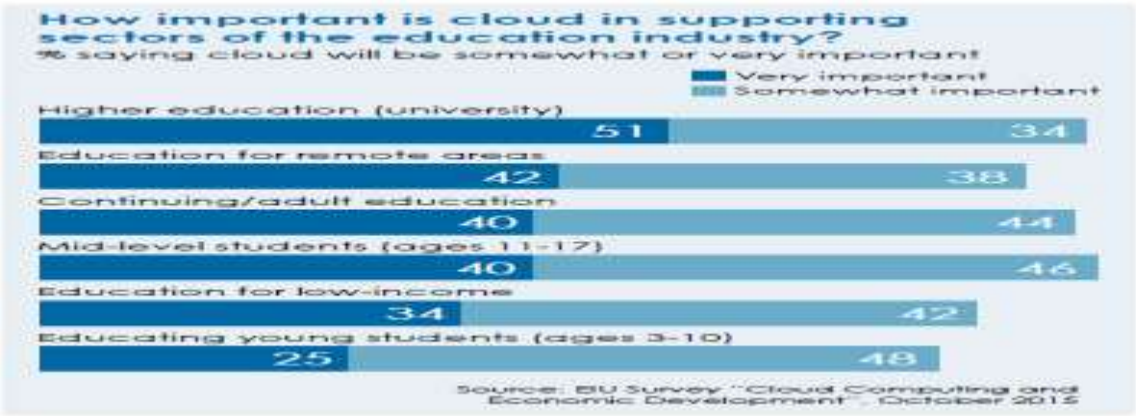


Figure 3.21 Importance of Cloud Computing for Education Sector (EU Commission Survey, 2015)

3.9.5 The Cloud Computing: Healthcare Sectors and its Impact

The healthcare as other sectors were bit slow to start using the cloud computing technology as compared to other industries as in there are concerns about the security and privacy of data using the technology in the sector. There were concern as there was confidential data related to patients are stored over the cloud. According to the EU survey results presented in the Economist: The Intelligence Unit, 2015, now there is a shift taking place in the healthcare industry where the use of cloud technology will support remote diagnostic and treatment for those patients who are in a remote location. The technology will ensure the empowerment of the patient who will have more control about their condition and this information is easily accessible to the patient regardless of their location. The technology will ensure the quick diagnostic of the patients and efficient treatment process without any delay. The participants in the subpanel in the conference more than 60% agreed that cloud computing technology in the next 5 years, will become a major part of the healthcare sector to meet the strategic objectives of the sector as seen from the Figure 3.22. Also there is a new trend that is emerging where cloud technologies are working together with the non-cloud computing technologies in the healthcare industry. The transition is taking place towards cloud technology but with the new shift where the cloud technology is working with the non-cloud computing is creating a large amount of concern in terms of data security, privacy and protection.

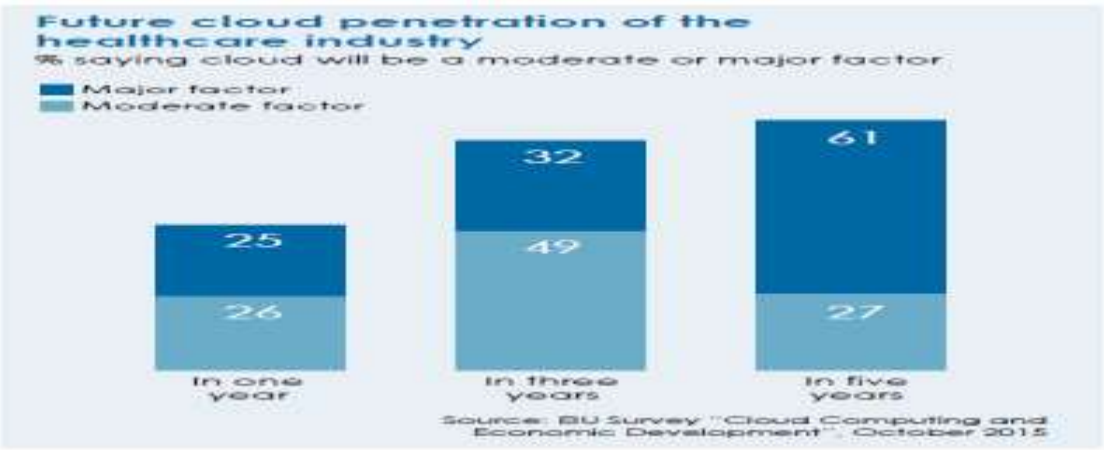


Figure 3.22 Cloud computing penetration in Healthcare Industry (EU Commission Survey, 2015)

The respondent gave a very positive outlook for using cloud technology in the healthcare industry where all patient records will be stored and accessed from a centralized location. The use of technology will improve the preventive care access and support low income families. The healthcare sector also in the survey agreed that using the cloud computing technology will improve the remote diagnose process and ensure the remote treatment which will save lives across the world. The majority of respondent in the survey as shown Figure 3.23, agreed that by using the cloud computing technology in the healthcare sector will provide quick treatment to the patients, improve the diagnostic process of the patients, provide healthcare to the remote areas where healthcare facilities cannot reach now, ensure treatment to start very early to save precious time resulting in saving lives of the patients.

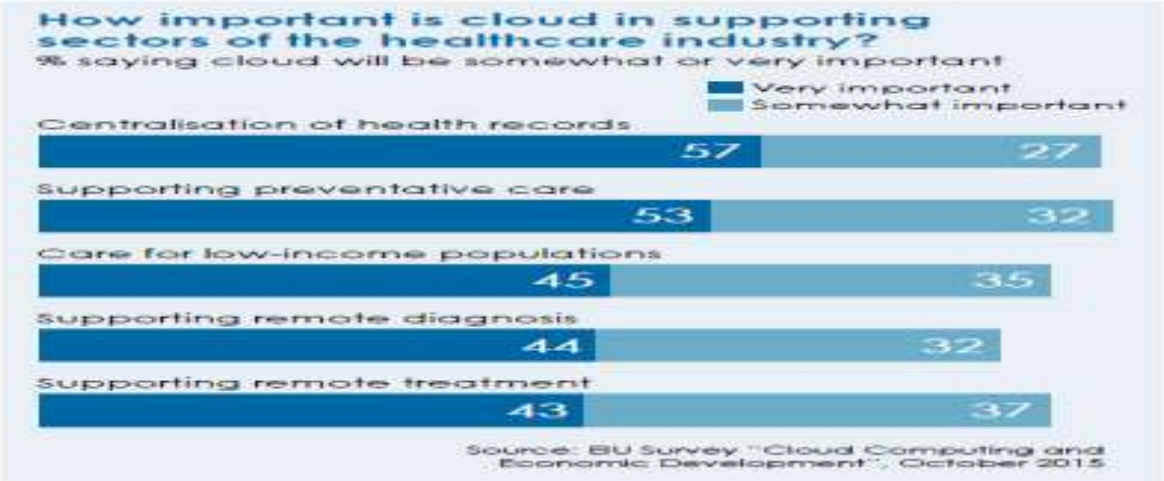


Figure 3.23 Importance of Cloud Computing for Healthcare Sector (EU Commission Survey, 2015)

3.10 Summary

The chapter provides a detailed insight into the cloud technology by providing an historical background followed by the various service and implementation model details. The chapter also compares Cloud technology with similar technologies and explain various commercial products. In the latter part of the chapter the adoption challenges of the chapter are discussed in-detail followed by the impact of cloud computing on various industries.

CHAPTER 4. Higher Education and the Cloud Computing Opportunities and Challenges

4.1 Introduction

The Cloud Computing technology is the latest technology that is revolutionizing the way users and businesses interaction and perform day to day activities. The technology is pushing the horizons of information technology and allows the use of systems by the remote users over the Internet (Tassabehji and Hackney, 2014). In the traditional model different components of the system were hosted locally but now the model is completely dispersed where all these components of the system can be managed externally away from the end user at a third party location (Pillay, 2014). According to (Simpson, 2015), the services that were hosted and managed internally now a small portion or the whole service is hosted by an outside third party. The emergence of cloud computing as a technology in the last few years have initiated a major movement from various organization regardless of which sector they are affiliated; to use this technology. For every organization innovation is necessary to manage the waves of change in order to compete effectively in this competitive world. Educational sector just like any sector is not immune to these drastic changes that are happening around us. The educational needs are increasing and the institutions have to expand their facilities by investing into infrastructure and other resources to meet the ever increasing demand. The need of the hour is that the educational institutions continue to adapt and incorporate new changes so they can manage with limited resources in an effective manner. With the internal changes in terms of new requirements that are affecting the educational institutions there are external changes that are forcing the institutions to improve productivity, efficiency with limited resources available. One of the major external factor that is demanding the HE institutions is to improve productivity with limited resources; is the existing global financial environment that is being experienced by all the economies around the world. The global economic outlook forecast is gloomy as all the major economies across the world are showing a downwards trend which will have serious consequences for all the sectors including the education sector (Simpson, 2015). Due to the financial slowdown, budget allocation for each sector has been tightened which demands an urgent action to be integrated by the education senior establishment to improve the productivity and efficiency with reduced budget. The limited resources of the institutions have to be managed and

deployed in an effective manner. Due to the economic crisis the world financial system is facing turmoil and its repercussion will continue to be felt in the next many decades to come. The crisis has put the government finances under massive constraints and the money available for education is less than ever before. The HE institutions are receiving less funds from the government and have to rely on other means to generate more revenue. The educational establishment have to review their internal processes and propose ways to reduce the cost of day to day running operations in this environment where there is limited budget. In this situation cloud computing is a suitable option for HE institutions which have limited budget requirement and it provides unlimited benefits such as flexibility, reduce initial capital cost and pay as use basis that can save a lot of capital and operational cost of the organization. The cloud computing provides these institutions with the next generation platform that ensures that all stakeholders in an organization share resources from the pool fairly, improve efficiency and reduce the cost. The adoption of cloud computing technology comes with a series of serious challenges and hurdles for the HE institution. These challenges can become an obstacle in more educational institutions adopting for the cloud computing technology. The chapter will initially discuss the HE sector and the factors that are influencing the change in the sector. In this section a model has been proposed identifying the internal and external influences that are affecting the HE institutions in the adoption of technology. The following section of the chapter will discuss the adoption of cloud technology in HE institutions and highlight the adoption methodologies that have been used by various HE institutions. Followed by explanation of various educational clouds that are being used by various HE institutions. The chapter will discuss the benefits and challenges of adoption of cloud computing in the HE institutions. In the last part of the chapter four various case studies of HE institutions that have adopted cloud computing technology are being discussed in detail. These case studies will be linked with the proposed model to explain the internal and external influences that are affecting the adoption of cloud technology to the HE institutions.

4.2 Higher Education and the Changing Scenario

The HE institutions are under immense pressure to improve the quality of delivery, produce a skilful workforce and provide affordable education that can add value to the economy (Alexander et al, 2008). The HE institution cannot maintain the status quo until they transform and integrate advanced technologies to maintain a competitive edge over others. In

this day and age the use of information technology and its importance cannot be ignored for the HE institution as it is helping to reduce cost, improve productivity and ensure that these higher education institutions can sustain in these global challenges (Vanquero, 2011). The computer revolution followed by the network advancement and now the latest development due to disruptive technologies has far reaching impact on all these sectors including the higher education sector. The position of HE industry is of uniqueness as they are a driver to the economic prosperity by producing knowledge based products and innovative solution that are according to the demand of the market (Wang and Xing, 2011). The use of technology and innovation will be differentiator factor for the quality of service offered by these institutions. These HE institutions have to integrate new modes of technologies such as disruptive technologies so that they can maintain qualitative edge over their competitors (Ouf, Nasr and Helmy, 2011). The use of cloud computing, social medium and big data analytics will ensure that the HE institutions are integrating new forms of learning into the curriculum.

The higher education is a place which initiates the forces of change and innovation. These institutions are burden with a key responsibility of ensuring communities and societies to develop and progress. According to (Guri-Rosenblit and Sebkova, 2015), the transformation in the society can only take place with strong relationship between the HE institutions, industry and government. This partnership will provide an opportunity for students, staff and researchers to reform the entire society and add value to the economy. In order to achieve this transformation the universities are moving towards extensive research which can only be possible by updating the information technology infrastructure so they can provide an environment that is suitable for research and development (Mircea, 2010) and (Marinela and Anca, 2016). The latest research is not possible in isolation, without the use of advanced technologies or using only the traditional approaches for scientific research. With the latest form of research there need to be strong partnerships between HE institution that are geographically divided across the world and involving the industry and government throughout the process. Due to the change in the scientific research methodology there is the transformation of technology taking place from the local data centres to online data centres to support this new scientific research methodology. The HE institutions have to adapt to these new changes by providing online resources that are abundant in their processing ability, provides guarantee with exceptional high uptime, processing ability and supporting large

amount of end users to interact with each other regardless of their location to contribute in the latest research and development (Ivan et al, 2016). These transformational changes are the requirement of new technological infrastructure to support the HE institutions day to day operation including research has inflated the expenses of the higher education (Golden, 2014). At the same time the financial forecast of HE institutions is badly affected due to the economic slowdown and less investment coming from the government. Due to these multiple pressures the HE institutions have to incorporate changes in all their operation such as services, processes, strategic and structure issues and technology transformation to continue to perform a quality services to all the concerned parties (Mircea and Andreescu, 2011). The author further explains that introduction of cloud technology can be an effective way to manage the financial situation the HE institutions are facing as well meet the new requirements for research and innovation. The traditional ways of teaching and learning are changing as there is an introduction of new tools that transform the way we learn and teach. The introduction e-Learning platforms are providing students and staff with variety of applications, hardware devices and huge storage of data in the cloud platform (Helmy, Ouf and Nasr, 2016). The author further stated that these platforms will enable enrich learning environment for students and staff to share their learning experiences. The HE institutions are also experiencing massive changes in terms of technological infrastructure and requirement of software applications are also changing which need to be adapted so that these institutions continue to produce highly skilled workforce. The author explains that the environment in which these HE institutions are operating is becoming really competitive and they need to replace the existing technology with advanced technology such as cloud based solutions and other disruptive technologies to meet the challenges of producing a highly skilled workforce.

The HE institutions are responsible to produce knowledge and knowledgeable communities that can add value to all the sectors in the economy. As mentioned by (Pampaka, Hutcheson and Williams, 2014), knowledge should not be static. It should always be challenged, always be improved and new forms and shapes of knowledge should be encouraged. If we do not innovate and improve; the knowledge will disappear or get obsolete. Same thing is true for HE institutions that they have to create knowledge, then continuously update knowledge by using the latest technologies and keep improving on the quality of knowledge. So it is paramount for these HE institutions to use technology and innovation to meet the demands of the global market. The technological advancement will continuously affect the HE

institutions and how they perform their responsibilities to contribute effectively to the ever changing global requirements

4.3 Cloud Computing in Higher Education Institutions

The previous section of the study discussed various internal and external pressures on the HE institutions such as economic slowdown, pressures on universities to improve productivity, efficiency and move towards research with limited resources. These HE institutions are facing huge demand from students for the use of advanced technologies and have to integrate the learning process according to the requirements of the business world. These internal and external pressures are moving the HE institutions to reform and adopt to these new technologies that can offer quality services to students and stay within the tight budget allocations (Williams et al, 2017). Cloud computing provides a platform for HE institution to provide services by using a third party resources that will completely remove the requirement of initial capital investment on the infrastructure and IT staff required for administration (Open Grid Forum, 2009). Still the concept of integrating the advanced technologies such as cloud computing in the higher education is very new. This was reinforced by the survey conducted by Gartner Consultancy UK, www.gartner.com , that mostly the cloud computing technology is being used by business sector particularly the finance section and the rate of adoption in the education is nearly 4% according to the following Figure 4.1.

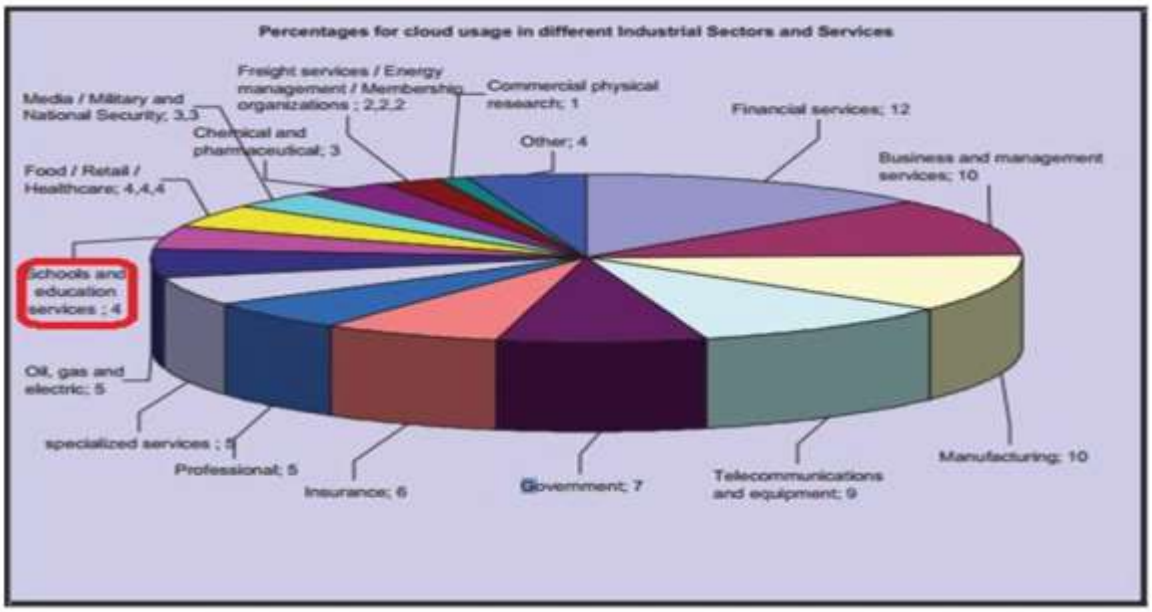


Figure 4.1 Percentage for Cloud Usage in different Sectors (Gartner, 2010)

The adoption of cloud computing technology in the HE institutions is showing upwards trend recently. In the EDUCASE Conference 2009, www.educause.edu, Bernard Golden, CEO of HyperStratus, identified cloud computing technology is valuable platform to reduce cost and produce applications with the fraction of the cost as compared to the traditional model. The speaker continues to explain that the use of cloud computing for HE plays a crucial role as of now these institutions with the limited budget cannot provide services to everyone. With the limited resources there should be prioritization and allocation should be based on the most critical requirements. The cloud computing provides an opportunity for these HE institutions to provide services to all the users within the limited budget. According to (McCrea, 2009), the use of cloud computing in the HE institutions will open up many possibilities in terms of research and development across the geographical divide also HE institutions will be more focus on the teaching and learning rather than configuring the complex IT systems. The use of cloud technology in HE institutions will reduce the complexities of system (Tout et al, 2009).

The use of cloud computing will introduce new method of teaching and learning. The technology can support the cooperative learning which will revolutionize the traditional approach to the instruction by allowing various instructors across the geographical divide to work in collaboration to teach (Thorsteinsson et al, 2016). The technology offers e-learning platform that is hosted by the cloud provider to be shared by all the stakeholders such as students, staff, researchers, business managers and government representative to share experiences and prompted new innovations. The e-learning platform will allow students to learn from the comfort of their home or while they are working or on the move. The cloud provider offers all the services, infrastructure, and applications by deploying virtualization and monitors the data used by all the users (Pocatilu, Alecu and Vetrici, 2009).

The HE institutions are adopting cloud technology to take benefit of the services offered by the technology. The initiative started by Virginia Virtual Computer lab is being used my many colleges and HE institutions in the developing countries to take advantage of the platform (Wyld, 2009). This platform is a prime example of collaboration and innovation where the institutions does not need any capital investment to buy all the expensive hardware, there is no need of investing in the licensing of software and the need of having a large IT

administrative staff is not required anymore. The other example of HE institutions using cloud technology is North Carolina State University that have reduced the expenses on staff and software licensing. According to (Wyld, 2009), the university was able to reduce the IT staff from 15 to 3 and reduced the overall IT budget. The GNIIT have deployed the largest cloud computing platform in collaboration with NIIT in Asia that provides students to learn at their own pace, and learners can be on the move or working but at the same time they can learn as well according to the Business Standard report in 2011. The learners can adjust their learning schedule according to their working hours and educational resources are accessible using mobiles or netbooks. The example of Kuali Ready (Bristow et al, 2010) is another example of HE institutions providing education by using cloud computing as a platform.

As shown from the Figure 4.2, according to the literature there are external and internal factors are influencing or considered as the adoption challenges to the HE institutions to adopt the cloud computing technology to meet the goals and objectives of the HE institutions. The external factors such as competitors, government policies, legal regulatory law and confidentiality and integrity concerns can be factor to adopt or considered as a barrier to the adoption of cloud technology. There are internal factors such as strategic goals, skill gaps, management and staff acceptance are the factors in the adoption of cloud technology. It is apparent now due to the economic challenges the cloud computing technology is necessary for the smooth running of these HE institutions. The pressure in these HE institutions are increasing due to inflation rise, operating cost is increasing, pressure of income to be increased, more students want to seek higher education, extensive demand for research with more competition (Sasikala and Prema, 2015). It is for paramount for HE institutions to adopt the cloud technology to meet all these challenges in an effective manner.

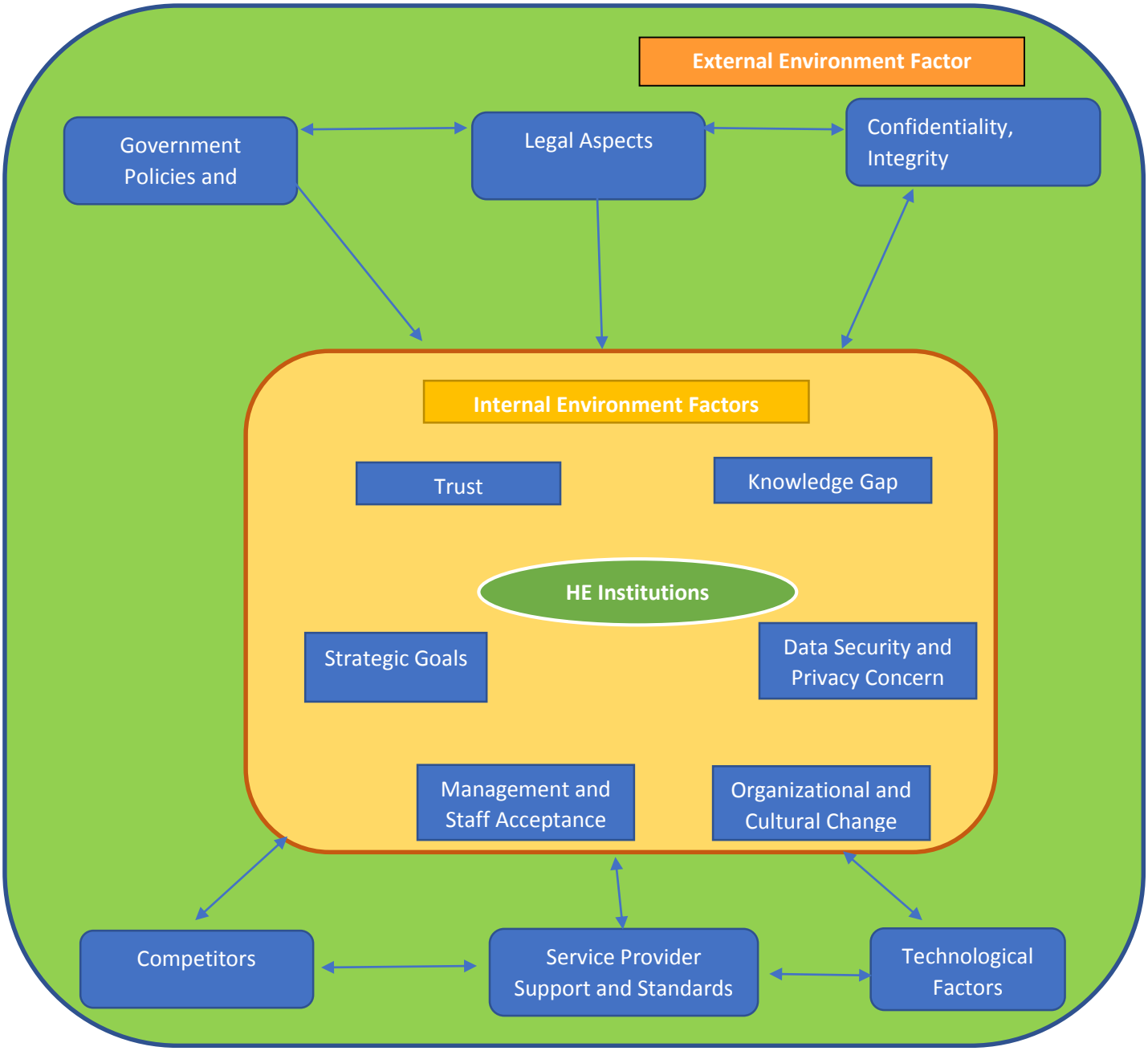


Figure 4.2 Higher Education and Adoption of Cloud Technology Challenges (Proposed by Researcher)

4.3.1 A Cloud Adoption Strategy for Higher Education

Due to the immense pressure on HE institutions the integration of advanced technological infrastructure with a cost effective option is the most important requirement to meet the ever changing requirements of the global job market. These HE institutions are also faced with dilemma to maintain their existing infrastructure and the cost of maintenance is growing with the time. In order to maintain the traditional data centres, the expenses related to the support

staff is an extra burden for the organizations. In order to manage all these pressures, HE institutions needs a new approach to the adoption of technology. The use of cloud computing technology can be a viable solution which allows the use of advance technologies but at the same time migrating towards the cloud needs a precise formulation of strategy that caters the needs of the business and extracting the maximum from the cloud computing capabilities. Using the cloud technology will enable HE institutions to form global teams and improve on communication and collaboration (Alshwaier, 2017). The use of advanced technology will ensure that researchers and academics to work together and produce quality research. For HE institutions the use of cloud technology will strengthen the working relationship between students and lecturers to interactive frequently, share documents and conduct work in collaboration (Brown, 2010a). The move towards cloud computing must be totally supporting the overall strategy of the organization (Sheelvant, 2009). In order to migrate towards cloud computing there should be detailed Service Oriented Architecture (SOA) and Business Process Management (BPM) or the migration process will be very expensive and it will not meet the strategic objectives of the HE institution (Scott, 2015). According to the (Mircea and Andreescu, 2011) the HE institutions who have recently migrated towards the cloud computing suggested the following migration strategy as seen from the following Figure 4.3.

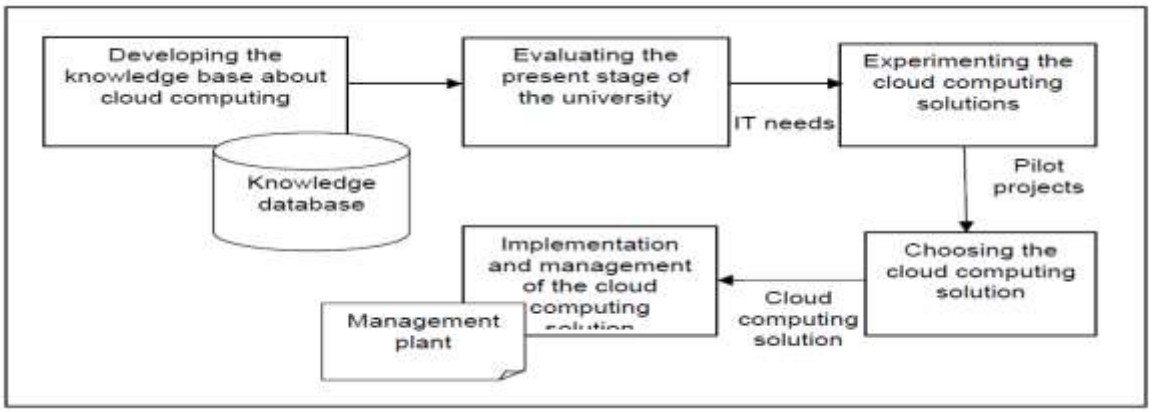


Figure 4.3 Cloud Implementation Strategy in HE institutions (EDUCAUSE, 2010)

- **Developing the Knowledge based about Cloud Computing:** According to the authors (Mircea and Andreescu, 2011), the most essential step in the successful migration of cloud computing technology in the HE institutions is to develop understanding about the technology among all the stakeholders. In order to develop the knowledge base it is to carry out detail research about the functionalities of the technology. Also encourage the participation in various seminars, conferences and focus groups to prepare the organization for the smooth migration towards cloud

computing technology. In this stage a focus team consist of information technology staff should be formed. The responsibility of this team is to carry out a detailed investigation into each cloud computing functions and how it can assist the layout of the universities. The team is also responsible to communicate with all stakeholders and concerned staff to have a detailed discussion about the key benefits of cloud computing solution and how it will resolve all the issues they were facing. This communication exercise will help all the stakeholders to understand more about the technology and how it performs. Eventually at the end of this stage there is a complete knowledge base compiled after detailed research and all staff can refer to this repository to improve their understanding.

- **Evaluate the existing stage of University:** At this stage of the implementation the authors (Mircea and Andreescu, 2011), explain that there should be detailed assessment of the existing requirements of the university. The assessment should define the existing IT requirements, data and services issues. During the evaluation the SOA (Service Oriented Architecture) should be used to define a baseline for data, service and application requirements for the HE institutions. The security policy should be reviewed and during the migration from the traditional model to the cloud it should be integrated in each process of the migration. The main end-users' groups should be defined and list of their IT requirements should be listed. In the HE institutions the four main end users' groups are students, lecturers, researchers and administrative staff that will be interacting with IT services department as it can be seen from the Figure 4.4. All these end users' groups will be able to access cloud computing resources such as email access, storing and retrieving data from the database, access Internet and manage all other application from anywhere at any time they desire to do so.

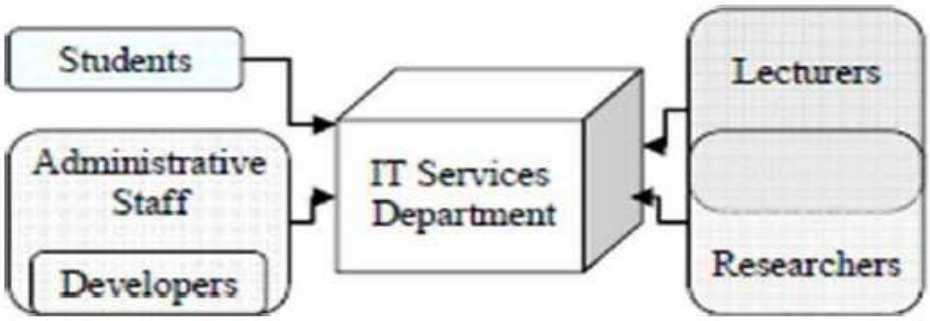


Figure 4.4 Main Users groups in HE institutions (Helmy Y, Ouf S, Nasr M, 2016)

All end user groups will take advantage of moving towards a cloud based solution in HE institution. Students by using cloud technology they can access information easily and while them are on the move. The model supports the information is readily available and can be retrieved regardless of the location or the device being used by the end user (Leavitt, 2013). Teaching staff can support their teaching by sharing all their resources such as presentation, study material using the cloud technology with the students in an effective manner (Pampaka, et al, 2014). With the use of cloud computing researchers can carry out detailed experiments with the use of latest technologies and collaborate the research process with other researchers across the world. These researchers do not have to worry about the underlying network infrastructure and technology as this is the responsibility of the cloud provider. They have to focus on their research and produce valuable contribution to the scientific field without taking into account the network configuration or infrastructure issues. Developers can design and test all advanced application using the data centre of the third party. The resources will be provisioned and re-provisioned by the cloud provider to support the application development. Users groups in the HE institution can use different cloud service models to perform various function as shown from the following Figure 4.5.

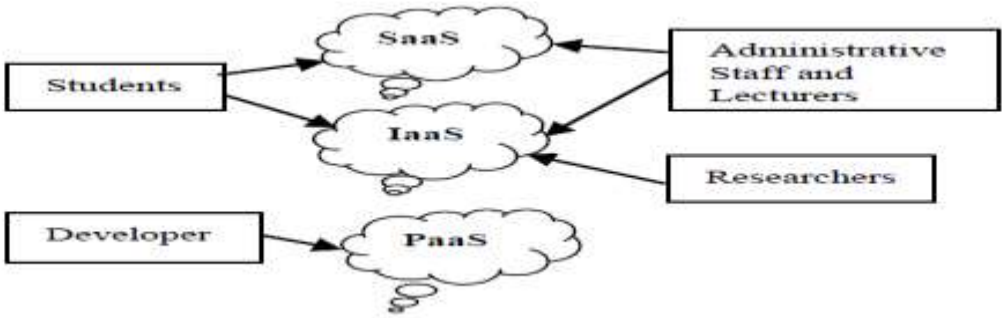


Figure 4.5 End-User groups in HE institutions using cloud services (Mathew, 2012)

- **Experimenting Cloud Computing Solutions:** Before the full implementation of cloud computing in HE institutions, it is crucial to carry out a testing phase to evaluate whether the transition towards the cloud technology will able to manage the entire work load according to (Mircea and Andreescu, 2011). A testing environment should be created and particular function in the HE institution should be selected for a pilot project. For this project some key targets such as amount of data stored, numbers of users using the application should be listed. The pilot project should run and all data related to each function should be collected so see whether it meets our desired goals or not. The testing stage is very useful as the HE institutions and its staff will learn

from this process before the full implementation. The outcome from the pilot project will provide a starting point to improve the transition process and ensure all problems to be resolved eventually.

- **Choosing Cloud Computing Solution:** Before selecting the particular cloud computing solution there are multiple consideration that were investigated. Initially in the HE institutions all data and key process were divided into the three main categories teaching, research and administrative tasks as seen from the following Figure 4.6.

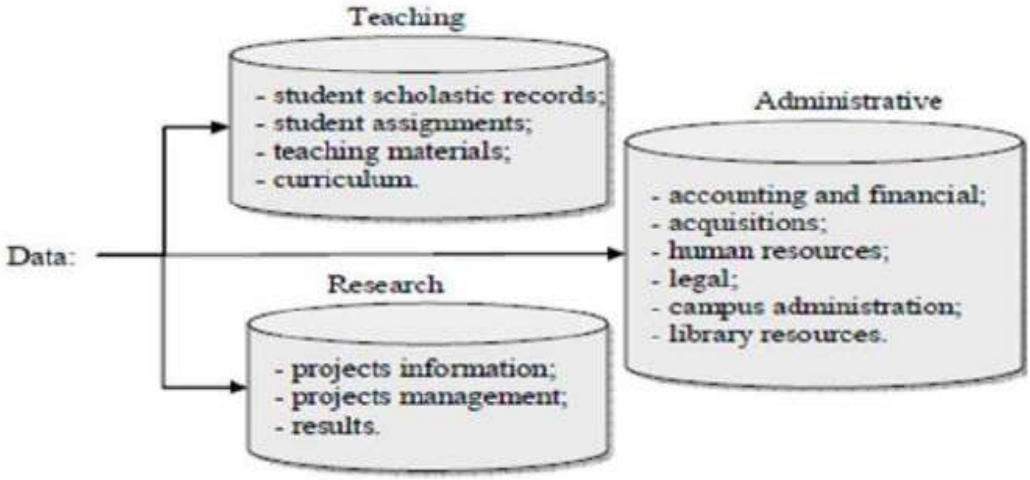


Figure 4.6 Three main functions of HE institutions (Mircea and Andreescu, 2011)

Then a detailed evaluation is carried out to identify the most critical functions for HE institutions based on sensitivity of data and functions that are directly aligned to meet the strategic objectives of the HE institution. The most critical functions are grouped together that needs the urgent attention and all resources should be deployed to smooth running of those particular function. At the end, the selection of the cloud model will be made for each functions based on the criticality and importance of these functions for the HE institutions. As shown from the Figure 4.7, the mission critical functions that are core to the processing for HE institution are hosted on a private cloud to ensure the confidentiality and data security of those functions whereas the non-mission critical functions that are not core will be hosted on the public cloud. Also these non-mission critical functions if they are core to the strategic objectives of HE institutions then it will be hosted on the private cloud otherwise if they are mission critical but non-core function they can be hosted on the public cloud as the data is not very critical important.

Business practices / Mission	Non-core	Core
Non-mission-critical	Public clouds	Private cloud or non-cloud
Mission-critical	Public clouds	Private cloud or non-cloud

Figure 4.7 Cloud selection criteria (Mircea and Andreescu, 2011)

Implementation and Management of Cloud Computing Solution: The implementation of cloud computing will go through a detail process of review; that is an iterative process where are functions and process will be tested and major improvement will be made. This process is based on a continuing cycle of evaluation of the cloud technology and whether it is meeting the desire goals and standards required by the HE institution. At this stage the introduction to the flexible program of risk management should be carried out to assess and resolve any risks with the continuous growth (Panopto, 2016). The data migration towards cloud should be based on set policies and procedures following all the controls and security (Mircea and Andreescu, 2011). According to the author there is a need of a comprehensive management model that defines all the security procedures and process to migrate data from the traditional model to the cloud option with speed ensuring that the data is accurate while transferred and maintains its confidentiality, integrity, availability and accountability. A comprehensive management model will ensure the quality assurance of data, processes and functions as all procedures are in place to ensure the smooth transition towards cloud computing solution.

4.3.2 Cloud Computing Structure for HE institutions

When the HE institutions are working in the cloud environment they should be well prepared for various challenges and issues such as data security, privacy challenges, authentication issues, interoperability, poor standards of service level agreement and concerns that staff will lose jobs (Bristow et al, 2010). The adoption of cloud model requires HE institutions to evolve and change their traditional way of working by overcoming adoption barriers such as policy management issues (Katz et al, 2015) and address cultural, lack of understanding

challenges and deal with the ever changing regulations. By fully understanding these challenges and issues HE institution will ensure a smooth transition and also an efficient working after the implementation of the model. The adoption of cloud structure completely depends on the type of the business. Some businesses are used to the change process and ready to take risks to improve while others are shy of any new change process and want to maintain the status quo. The senior management of a HE institutions should have a desire that their institution should excel in the field of research and development so they will try to adopt completely to the cloud model as it provides an infrastructure to support research and development process and support e-learning. As it can be viewed from the following Figure 4.8 all key processes of HE institutions can be supported by the cloud model which will enable the institution to meet its goals and objectives.

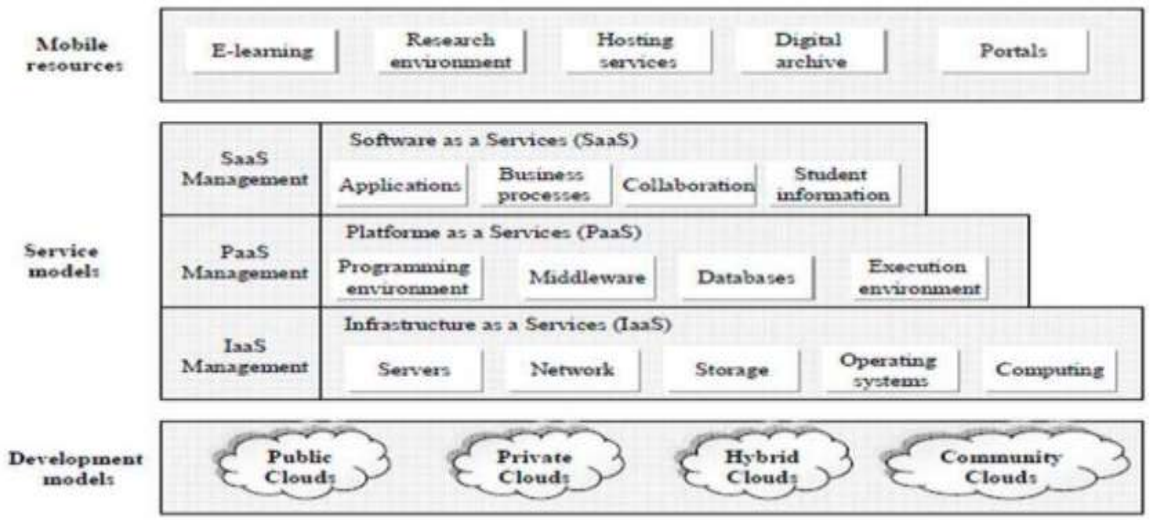


Figure 4.8 Cloud Architecture model for HE Institution (Katz, 2015) and (Mircea and Andreescu, 2011)

In order to develop a cloud model for HE institution can be a challenging task as these institutions have to abide by fixed rules and regulation of the countries where they are operating. There are few countries that do not promote the transferring of data and information across the borders of particular country where the data is being hosted from according to (Zhu, et al, 2016). The HE institution has to agree on the location of the data storage according to the law of the state, then the next stage in the most problematic is the formulation of SLA (Service Level Agreement) between the HE institutions and the cloud provider that can meet the requirements of the client. HE institution have to be prepared for a very length process in which they have to negotiate with various providers as to agree on SLAs which is very tedious tasks and different providers providing with different set of

services as there is no uniform model in the market. The SLAs have to be agreed for data privacy issues, integrity, authentication, identity management and audit and control process which is very lengthy and complicated process that has to be taken in place between the HE and cloud provider. Due to lack of uniform Service Level Framework there is confusion in the adoption of service as well different quality of service offered by different cloud providers according to (Fogel, 2016). The following Figure 4.9 shows various cloud architecture used by HE institutions.

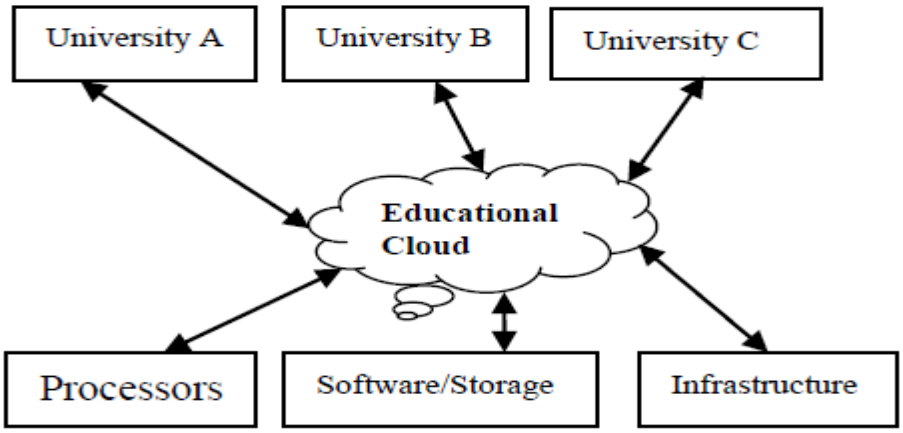


Figure 4.9 Education Private Cloud Architecture (Mathew, 2012)

HE institution can deploy their own private cloud for data security and privacy. These institutions can develop these cloud further by adding more resources and managing the entire administration. The private cloud will be used by the specific institutions and their students only. The next model promotes more collaboration where more than one universities can work together to develop the cloud known as hybrid cloud where multiple universities can share resources and work in collaboration. In the private cloud only limited staff and students from that particular university can access or share resources whereas access to educational cloud model can be based on subscription. The private cloud can be controlled and managed by the particular HE institution that have the proprietary rights and no one else can make any changes. The cloud model used in the educational institutions will be based on demands of these institutions. Each model will support HE institutions based on their specific requirements as shown from the Figure 4.10.

Cloud Feature	Private Cloud	Educational Cloud
Owned and managed by	Single university	Service Provider (many universities)
Access	Limited to employees and students of single university	By subscription
Control and customization	Yes (By university)	None

Figure 4.10 Difference between Private and Educational Cloud (Mathew, 2012)

4.3.3 Education Clouds Services in Higher Education Institutions

The educational clouds are providing effective services to the HE institutions. Many organizations such as Microsoft, Google, Amazon and IBM have played a vital role in the development of various educational platforms and tools using the cloud computing technology to support and promote the learning process. As the following Table 2, highlights some of the educational clouds which provides an effective models of learning for students where they can access all educational material online regardless of their location.

Commercial Product Name	Education Cloud apps	Features
Microsoft Education Cloud	MicrosoftLive@edu	Website Creation File sharing Word processing Desktop sharing Resource scheduling
Google Education Cloud	Google Apps Education (GAE)	Google Mail Google Sites Google Docs Google Video Google Calendar Google Talk

Earth Browser	Earth Browser	Provide real Time data for weather, geological and other data
Socratica	Socratica	Classrooms in science to access Create and study modules
VMWare	Virtual Desktop	Provide Virtual computers
IBM Cloud Academy	Virtual computing lab	Smart analytics system

Table 2 Cloud Education Models (Razak, 2009) and (Alshwaier, 2017)

- **Microsoft Education Cloud:** The Microsoft was one of the first companies to introduce educational services through the use of cloud computing technology. The Microsoft 365 is the best example that provides educational institutions with email without any cost, provide storage capacity to store educational data up till 25GB space and a website for personal use (Arjun and Vinay, 2016). The model allows students and teachers to interact with each other to discuss various educational contents and online students can create documents and presentation using different software packages (Ivan et al, 2016). The drawback of this model was the monthly payment option that user have to pay which can be an increased burden for a many years to come according to the author.
- **Intel AppUp Center:** This site acts as repository of all the educational resources and provides access to these resources using mobile devices. All educational material from various institutions and teachers are catalogued here for the access. The site provides a detail model of how educational resources can be shared across any geographical boundaries using cloud services.
- **iTunes University:** This platform is considered as one of the biggest resources to share educational material such as latest resources, white papers, lecture and assignment. This website provide support to a very large audience and this is only

possible due to cloud computing infrastructure that is providing enough scalable resources to meet those large scale demands.

- **Google Education Cloud:** The platform provide a major collection of educational material to all the end users without any charges. That is the reason this application is very popular among all the educational communities (Jay, 2014). The application provides lot of facilities to its users by providing an email hosting service, users can store their data using Google Education Cloud. The application allow students to access educational material and perform various functions such document writing, preparing presentation and other office administrative tasks (Google, 2015). This application provide an opportunity for the academic communities to innovative their teaching and learning methodologies and adapt to requirements of the learners. The cloud technology is enabling this model to work effective and share resources.
- **Socratica:** This application using a cloud computing technology produces educational videos for target audience of all age groups to watch videos and learn (Socratica, 2015). These high definition videos are related to various educational content and provide a different way for teaching students. Students can make their own educational videos and share it with other users as well. This application is cloud technology to meet the large bandwidth and throughput requirements.
- **IBM Cloud Academy:** The motivation behind this model was to provide an opportunity for various educational communities to collaborate and share educational material so that the cost is reduced and quality educational material is easily available (IBM, 2014). The model provides an ecosystem for research and development where all educational communities share resources that are easily accessible. The model leads the way in improving the quality of teaching and learning, provide a platform for students to learn easily and share their experiences (Razak, 2014; Ketel 2014, Mathew, 2017; Alshwaier, 2017). This is only possible by integrating cloud technologies into their infrastructure so that all users can take advantage of the technology and seek education regardless of their location and circumstances.

The cloud computing provides a large amount of benefits such as proving a platform to share resources in a reliable manner. The benefit of using eLearning systems includes access to educational resources, provides mobility for the end-user, provide options for the users to access resources and learn the way they prefer and according to their work pattern (Pole et al, 2017). These e-learning systems reduce the setup cost with no capital investment required

and provide a scalable platform where resources are provisioned from the shared pool based on the end user demand. These VLE (Virtual Learning Environments) are changing the traditional forms of teaching and learning by introducing new trends in these HE institutions (MacNeil and Kraan, 2017). The survey by (Weller, 2006) for "Institute of Education Technology" found that more than 86% respondents from various HE institutions are using different VLE for education. The survey also indicated the most important VLE in the education market as Blackboard, Moodle, Sakai, SharePoint and Skool that are helping all stakeholders in the educational institutions to work together and learn from each other's experiences in an effective manner.

The above educational cloud services has completely changed the traditional way of learning in the classroom and provided an opportunity for everyone to collaborate together to share resources, access educational materials and every individual can seek education according to their own learning habits.

4.3.4 Trend in Higher Education for Cloud Computing: Benefits and Challenges

The HE institutions are gaining the benefits of using the cloud computing technology. The rate of adoption for each case will depend on various factors such as cultural understanding of the technology, level of motivation to keep improving, ability to accept risk, existing contracts and any government legislations. But it is evident from various studies that there is movement towards the cloud technology to gain the benefits of this model. The decision of using cloud computing in the higher education will bring major benefits and also large of amount of challenges and risk associated with this new shift. Before the decision is made all the factors should be considered whether the new move is aligned with the strategic goals and objectives of the HE institutions or not? During the decision process the HE institution's management should also consider that if they continue to work with the traditional model what risks are associated with maintaining the status quo. As mentioned by (Patterson et al, 2010), all factors should be considered while opting for cloud such as all risks will be transferred to the provider but at the same time issues for data security, confidentiality, integrity and availability should be also considered. The other major challenge that need to be considered is the lack of uniform service level framework which affects the quality of service

and considered as an adoption barrier to the technology. All these factors should be considered before the final decision is made. In this section of study, various trends, benefits and challenges in the HE institutions using cloud computing technology will be examined. This section will provide the opportunities and challenges faced in the adoption of the cloud computing technology. In order to support this section, a survey conducted by eCampus News (2015), www.ecampusnews.com, that was sponsored by ViON corporation in 2014 will be used. The survey was focused around staff that were in leadership and management roles at higher education institution from various departments. The target audience also includes information technology managers, academic staff and students from various colleges and universities.

According to the above survey the first trend that was highlighted was the overwhelming respondents were aware of the cloud computing as a technology. Nearly 88% was respondents stated that they have high or moderate knowledge about the cloud technology and nearly 27% agree they are cloud expert in their educational organization whereas 61% agreed that they can have a knowledgeable discussion about the cloud computing technology. This clearly shows a trend that the general awareness about cloud technology in the HE institutions is very promising and overwhelming majority is familiar with the technology. The next major trend that was highlighted due to the survey was that nearly 80% of the respondents stated that their institutions is using SaaS (Software as a Service) model which is way higher than the 39% who responded by stating IaaS (Infrastructure as a Service) followed by 22% for CaaS (Communication as a Service) and only 18% stated PaaS (Platform as a Service) as shown in the Figure 4.11.

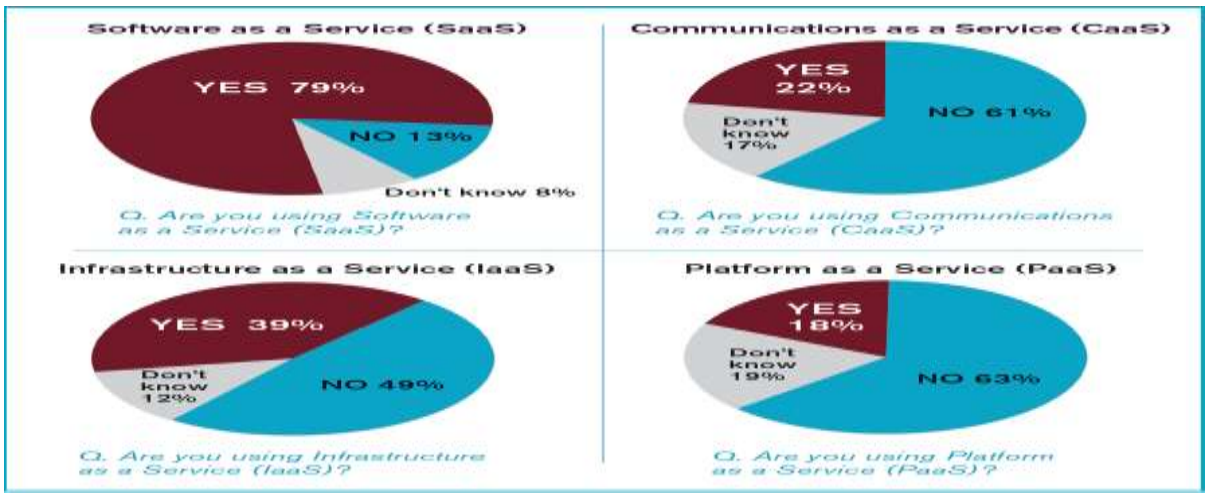


Figure 4.11 Use of various clouds models at HE institution (eCampus News Survey, 2015)

The responses clearly show a trend that HE institutions are using various cloud models in order to provide quality education and meet the demands of the students. The next response indicates the trend that nearly 66% of respondents agreed that email is the most used application in the SaaS model followed 55% of popularity for online learning tools and 42% productivity tools. The survey also highlighted various other application that are being used in the SaaS model in the HE institutions are customer relations management (CRM) that is 27%, human resources management is 25% followed by Video management and content management that is 23% and 21% respectively. The trend highlighted from this response is clear that students are using various applications such as emails and learning management system using the cloud model in a majority that shows the level of comfort of the users using the technology. Apart from various other applications are also being hosted on the cloud computing technology which is an optimistic sign for the cloud industry.

The next trend that was highlighted in the survey was that apart from SaaS model the HE institutions are using service model IaaS for various application as shown in the Figure 4.12. According to the respondents' top service in the IaaS was the used is servers according to the 66% respondents followed data storage with 63% respondents agreed and 31% agreed in using cloud for hardware services as shown from the following figure.

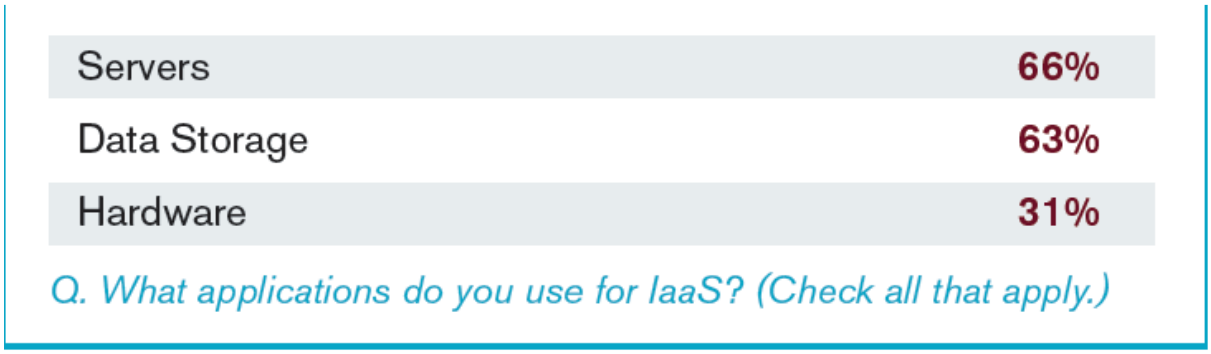


Figure 4.12: Top three IaaS Services (eCampus News Survey, 2015)

The trend is apparent that more and more respondents are using IaaS services to perform various tasks in the HE institutions. The next trend that was highlighted in the survey was that in the majority HE institutions want their data and services to be privately hosted so they have more control over their data. As you can from the following Figure 4.13, the majority of respondent wanted to use a private model to host data in SaaS 54% and PaaS 57%. The responses collected also show a trend that these HE institutions use different cloud service

models to support various applications. So far the use of community cloud in HE institutions is very low and it needs further attention.

	SaaS	IaaS	CaaS	PaaS
Private	54%	46%	51%	58%
Public	38%	31%	34%	27%
Hybrid	15%	28%	23%	8%
Community	2%	3%	6%	4%
Don't know	8%	13%	11%	12%

Figure 4.13 Private Cloud demand of HE institutions (eCampus News Survey, 2015)

The trend was showing that majority of HE institutions for all cloud service models are paying from their operating expenses as compared very few paying upfront as a capital expense as mentioned in the Figure 4.14. The survey confirms that the HE institutions do not have to invest a large capital upfront to buy expensive hardware, software and applications. The trend is having a huge ramification for the HE institutions that can use the saved money for research and development rather than buying hardware or pay a large IT administration staff as shown from the following results.

	SaaS	IaaS	CaaS	PaaS
Operating expenses	76%	72%	63%	84%
Capital expenses	5%	9%	9%	8%
Don't know	19%	19%	29%	8%

Figure 4.14 Institutions Payment Plan (eCampus News Survey, 2015)

The majority of respondents agreed the use of cloud technology has brought a large amount of convenience and benefits to them. More than 63% agreed that the use of technology has allowed easy access while 62% agreed that they can learn while on the move as shown from the Figure 4.15. This feature is very important as students learning styles are changing and they want to access educational material and learn on the move. The same is true for

academic staff and senior managements that due to the change in the nature of their work as they are traveling; they also agreed that the cloud computing allowed easy access to the resources to complete their work while they are on the move. The benefits of cloud computing to HE institutions are many with 53% agreed that use the cloud technology has made it easy for automatic updated and patch management, 52% of senior management agreed that cloud computing has resulted in cost saving followed by improved efficiency and easier administration 51% and 43% respectively.

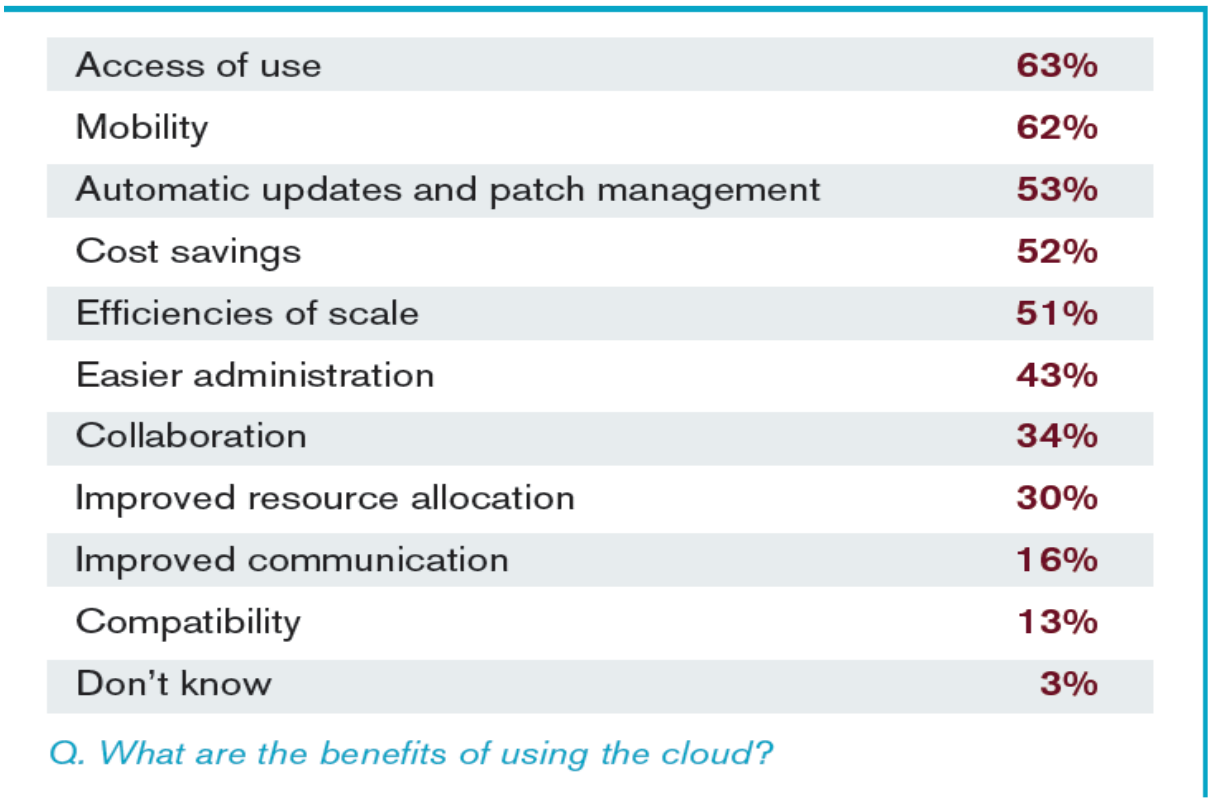


Figure 4.15 Benefits of using Cloud Computing in HE institution (eCampus News Survey, 2015)

With the benefits come large amount challenges of using cloud computing in HE institutions. As per respondent more than 68% are really worried about the security of data by using a third party provider. The data security concern is far ahead of any other concern raised by the respondents. Losing the ownership of the data is also a major concern for the respondent in the HE institutions and then data privacy is also considered as major concern for the respondents. It clearly indicates a pattern that the respondents are worried about the security of their data and its privacy can be compromised due to lack of controls. These concerns can affect the CIAA Triad (Confidentiality, Integrity, Availability and Authenticity) which can effectively hinder the transition to the cloud computing technology in the HE institutions. As one of the respondent stated the data security and privacy is the major challenge and

compromising on data leakage is an obstacle to adopt the cloud services. The respondents were also worried about the process to agree on SLA (Service Level Agreements), contract issues and compliance challenges due to lack of uniform standards in the service level framework which are a major adoption barrier in the implementation of cloud technology in the HE institution as shown from the following Figure 4.16.

Figure 4.16 Cloud Adoption challenges in the HE institution (eCampus News Survey, 2015)

4.4 Case Study: Cloud computing model for Malaysia Higher Education

For Government of Malaysia the importance of quality higher education is very important for the economic and social development of the county. The government is allocating nearly 20% which is 54RM billion of the federal budget for education only according to (Ministry of Education, Malaysia, 2016). This enormous amount of allocation shows the importance of quality education and human capital development for the country. According to the figure of Ministry of Education, Malaysia the amount of money reserved for education in higher than all OECD (Organization for Economic Co-operation and Development) average 3.4%. The government of Malaysia is promoting high quality education by using the cloud computing model. According to (Kalim, 2013), the use of cloud computing technology in the HE will bring innovation which will result in a high adoption rate of the technology in the HE institutions. The authors further explain that the use of technology will reduce the operating cost, allow all stakeholders to share information, education can be in the approach of the people with ease access, promotes the research and development by collaboration and provide massive data storage space for the end users.

Higher education institutions will be able to reduce the cost with the implementation of cloud computing solution (Arora, Indu and Gupta, 2012) and (More, Vij, and Mukhopadhyay, 2017). The senior management of HE institution does not have to acquire expensive hardware and software applications; the same money can be invested in improving the front line services for the educational institutions. Using the cloud computing model the Ministry of Education, Malaysia will be able to collect all data related to numbers of students, their attendance, grades, numbers of teachers, and up-to-date information on each institution can be collected so that it can be analysed by the senior management (Gurmeet and Vineet, 2012). The technology will enable to provide a detail view of all the HE institutions and help to make strategic decision in an effective manner without wasting any time. The following model allows all HE institutions to share resources from the shared pool. The resources are provisioned to each HE institution based on the demand and re-provisioned accordingly. Due to the cloud model the resources are utilized in an effective manner and allow all stakeholders to have an equal share of resources as shown from the Figure 4.17.

Figure 4.17 Educational Cloud used in Malaysia Higher Education (Gourmet, 2012)

4.4.1 List of Benefits and Opportunities

The use of Cloud Computing technology in the Malaysia higher education institutions provides a collaborative environment where all institutions can work together, share their experiences and add value to the teaching and learning activities. According to (Arora, Indu and Gupta, 2012), the cloud computing allows all universities to upload resources, files, videos and other research material on the cloud that can be shared across all Malaysia universities and their students. The author provides an example of Northern University of Malaysia (UUM), which offers a rich learning environment in the form of e-learning that provides access to the educational material to thousands of students regardless of their location at the same time. The Malaysia educational cloud provides a large storage space so students from various educational establishments can upload documents and share it with others students in a different university. The cloud educational platform can allow to share resources between the lecturers and students without having any face to face interaction. With the cloud computing educational model students can receive quality education regardless of which university they are based. The following section highlights the key benefits that the Malaysia higher education system will achieve by using cloud computing technology:

- With the use of cloud computing technology in Malaysia HE institutions, there is no capital investment required on the infrastructure which can be very beneficial for the business. The HE institutions can save this money and invest in improving services rather than acquiring new hardware and software;
- The use of cloud computing in the HE institutions can provide educational network that can be shared by all students across the country. This will provide an opportunity to produce knowledgeable individuals who can contribute to the economy effectively;
- The implementation of HE cloud across all the universities in the country provides the same resources, material and streamline the processes. By implementing the same procedures and processes it will ensure the same standards across all the HE institutions in the country. This will improve the standard of teaching, learning and research across the platform (Shahzad and Saleh, 2016);
- The use of educational cloud has reduced the cost of licensing new software. Using the traditional model a large amount of budget was spent in acquiring various licenses according to (Shahzad and Saleh, 2016). By using the educational cloud in HE institutions the cost of licensing is not required. The library and research activities can built e-learning portals which can allow sharing of all resources and applications without the cost of acquiring individual licenses for each university;
- The use of cloud technology in HE institutions has reduced the overhead cost across the country. More work can be performed with less workforce and the time to learn new things is reduced by the implementation of user-friendly technology (Sultan, 2010);
- The use of educational cloud in HE institutions will provide a comprehensive disaster recovery system for all institutions. There is only a single data centre that will be responsible for disaster recovery for all the universities across the country. This will reduce the cost for disaster recovery and allow the institutions to use the same resources to provide better services to the students.

4.4.2 List of Challenges and Problems

The use of cloud computing technology in HE institutions can play a vital role in the improvement of teaching and learning facilities. With the benefits of cloud computing comes

the challenges and problems of the technology for HE institutions. The challenges that are faced by HE institution in Malaysia are daunting and related to the areas such as management, contractual issues and legal compliance, technical, security and services area. In the following section some of these challenges faced by HE institution in Malaysia will be discussed:

- The country is still progressing and making socio economic development. The major hurdle that is faced in the implementation and the use of cloud computing is the variable quality of speed and connectivity issues related to Internet across the country. In Malaysia the standards for Internet speed is not consistent between the major cities and other rural areas. Some universities due to their location cannot be connected to the cloud or the speed of the Internet is a major barrier to take full advantage of the cloud computing. In order to take full advantage of the cloud computing all HE institutions regardless of their location should be able to access high speed Internet access. With only consistent high-speed Internet access offered by cloud providers regardless of their location the HE institutions will be able to take full advantage of cloud technology by storing and accessing data quickly (Shahzad, 2016);
- The next major problem faced in the adoption of cloud computing technology in HE institutions in Malaysia is lack of quality of service standards provided by the main cloud provider. There is no uniform level of service standards and the quality of service and standards provided by different providers are not consistent with each other due to lack of uniform framework to measure their (cloud providers) performances. Due to poor level of service level and lack of standards offered by various providers in the country it becomes a difficult task in the selection of service by cloud users. The challenges related to lack of uniform standards or nonexistence of minimum benchmark for level of services across the cloud providers in the country is creating barriers to the adoption of effective, uniform and reliable service to the HE institutions in the country. As the cloud computing is gaining popularity in HE institutions across the country, the inconsistency in the level of service offered is not allowing the students, staff and all stakeholders to take full advantage of the technology. The situation becomes more critical due to distributed nature of the service provider which can be offering service from any part of the world. Due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the HE institution there are serious concerns raised recently in-

terms of data security and privacy breaches, authentication and authorization, lack of third party audit and identity management, integrity and variable availability standards, confidentiality and no uniform incident response and monitoring standards raised by the users (Klingert et al, 2016).

- The other challenges that was faced in the adoption of cloud technology in the HE institution was the concern of data security and data privacy from various stakeholders such as students, staff and various individuals working in the administration of HE institutions. To switch towards cloud technology data privacy and its security is a major challenge as higher education contains sensitive information, personal data and any future strategic plans can be at risk if the data is hosted on a third party servers. The data owners in this case study (Malaysian HE) institution, have shown major reservation to the adoption of cloud computing in HE institution due to data security and privacy concerns about the data. This concern was a major barrier to the adoption of cloud computing technology in the HE institutions in Malaysia. The data owners were worried about the lack of control over their data which will be stored by a third party servers;
- The next barrier or implementation challenge was that due to variable quality of service offered by different cloud providers there can be legal and compliance issues which can create problems for Malaysian HE institutions. So far as there is no uniform set of standards that is agreed by all stakeholders, there are concerns related to data protection and confusion about the responsibility of safeguarding the personal data that is stored over the cloud provider.

4.4.3 Case Study Contribution to the Proposed Model: Higher Education and Adoption of Technology Challenges and Changing Scenario Model

The Malaysia HE institutions is facing the same external and internal issues mentioned in the proposed model already described. In the following section different factors from the proposed model that have affected the Malaysia HE institution will be discussed in detail.

- **Government policies and Economic Factor:** The Malaysia HE institutions were spread across the country and it was very difficult to have a centralized management control system that can provide coordination and control of all these HE institutions. The next factor that has influence the adoption of cloud technology in the HE

institution of Malaysia is the government policies and economic realities are the key factors that are influencing the adoption of cloud technology in the HE institutions in the country. Each HE institutions had their own IT staff to maintain the site specific network that was resulting in a large capital investment to acquire all the expensive hardware and software for each HE site with a very high operating cost (Ismail, 2016). The government of Malaysia designed a detailed strategic plan to overcome these issues and decided to shift towards cloud computing platform to reduce the expenditure to maintain the traditional data networks (Saleh and Shahzad, 2016). With the adoption of cloud technology now the staff at Malaysia HE institutions can focus on providing excellent quality of teaching and learning and improving research rather than worrying about buying new hardware, upgrading software license and issues such as purchase and logistic. The government can save a large amount of capital investment and reduced the operating cost by moving towards the cloud computing platform. But there is lack of uniform service level framework provided by all the cloud providers so the government policies cannot be implemented fully and there will be different quality of service offered by cloud providers;

- **Technological Factors:** The move towards cloud technology there will be no need to acquire new infrastructure and all IT maintenance will be carried out by the third party provider. Also the Malaysia Education Ministry can easily monitor the performance of all HE institutions from a central location. There was a requirement from various sectors of the population to reduce the electricity consumption and move toward green computing. The move towards cloud technology by the HE institutions helped efficient use of key resources and promoted energy saving mechanism. With improve resource utilization and saving energy consumption there are various technological challenges in the adoption of cloud technology such as resource exhaustion, lack of standard of services, not predictable level of performance, issues such as data transfer bottleneck and data lock-in uses that need to be addressed. As there is no uniform service level framework that can measure, assess, evaluate and make cloud providers accountable for the quality of service offered there can be serious implementation issues in the implementation of a cloud based solution in the HE institutions across Malaysia;
- **Data Security, Data Privacy and Legal Factors:** The next factor that has influence the adoption of cloud technology in the HE institutions in Malaysia is the data

security and data privacy issues. Any breach in the data security and privacy will have impact the reputation of the HE institutions in the country. The concerns that were raised by all the stakeholders in the HE institutions was the risk of losing data or network breach that can result in the loss of confidentiality, integrity and availability of data while storing data on the cloud provider (Shahzad, 2016). The concerns related to storing the data on a third party server is a lack of control over the data and if the providers fails to separate the resources this could lead to serious security risks. So far the country does not have string legal legislation on data protection or data privacy so the standards of service offered by the cloud provider is not consistent. This data security and privacy issues were the barrier in the adoption of cloud computing in the Malaysia HE institutions;

- **Service Provider Standards and Level of Service Factors:** The next factor that has influence the adoption of cloud technology in the HE institution of Malaysia is the level of services offered by the cloud provider in country. There were serious concerns raised by all the stakeholder in the HE institutions due to lack of uniform standards, nonexistence of (QoS) Quality of Service offered by the cloud provider and of minimum benchmark for level of services across the industry to provide an effective, uniform and reliable service to all the cloud users. As the cloud computing is gaining popularity the HE institution in Malaysia are having problems to adopt the service due to lack of minimum service level framework or poor and variable QoS (Quality of Service) offered by the cloud providers in Malaysia. The standard of service which can act as a benchmark in the selection of the cloud provider and provide quality of services according to the users expectations is not available among the cloud providers. Due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the industry there are serious concerns raised recently due to poor level of standards offered by different cloud providers that is resulting in security and data privacy breaches, authentication and authorization issues, lack of third party audit and identity management problems, integrity and variable availability standards, confidentiality and no uniform incident response and monitoring standards;
- **Management and Staff Perception and Acceptance:** The next factor that has influence the adoption of cloud technology in the HE institution of Malaysia is the acceptance of management and staff to adopt the cloud technology and their

perceptions related to this new technology. The HE institutions in Malaysia faced a barrier from some quarters in the management and staff who were worried with the adoption of cloud technology in HE institutions due to data security and privacy challenges. The perception of all stakeholder who want to use the technology must be considered and addressed before the adoption of cloud technology in any environment.

4.5 Case Study: Cloud computing model for U.K Higher Education

The technology is revolutionizing the way we perform our normal day activities. With the integration of technology and especially cloud computing technology into education the whole sector has been reformed where the initial capital investment required to have and maintained expensive hardware and software is removed. It is more affordable to maintain the operations and provided new businesses an opportunity to invest the same money in other areas, maintain high quality and operate in the tight budget. Due to the current economic climate and with limited budget for public sector the UK HE institution have to change and adapt to these external pressures according to (Miksch, 2003). The Higher Education Funding Council for England (HEFCE) is rigorously promoting the drive for the adoption of cloud computing technology in the UK HE institutions (Alshwaier et al, 2017). The initiative provides financial and technical supports for all HE institutions to move towards cloud and provides all services to its audience using the shared platform of cloud computing. There is a huge pressure not only in terms of financial constraints in the public sector also huge pressure is being faced in order to incorporate new technology and improve the way we perform daily operations. Also various competitors around sector are trying to provide education that can produce a skill workforce according to our market demands it is necessary to use the latest technologies. In order to meet these challenges another funding initiative has been introduced in UK HE institution is from University Modernization Fund (UMF) that is responsible to introduce cloud computing facilities such as various suites of applications, provide technical support for data management, storage and advice in securing off site servers (Tobias, 2014). The cloud computing decision has large benefits but at the same time has serious concerns that are being raised as data storage facilities are outsourced and the owner of the data has a lack of control.

The UK HE institutions are facing a shift towards the cloud technology. The support for HEFCE in 2011, helped established the Joint Information System Committee (JISC) and investment of more than 12.5 (Million pound sterling) to provide a shared cloud platform for conducting latest researches and sharing of educational resources (Hitchcock et al, 2005). The UK HE institutions such as Kent, Exeter, Oxford and many others were the partners in the implementation of cloud based solutions. The involvement of the private sector is very crucial for any initiative to succeed. For the adoption of cloud technology in the UK HE institutions various private sector companies such as Microsoft, Google and Apple started providing cloud based applications to support education (Ismail, 2016). The author further explains that with more competition from the private sector HE institutions in UK are taking advantage to build off-site email system that is without any cost. The University of Westminster has adopted cloud technology that has resulted in the saving of more than (1 Million Pound sterling) for the university as they do not need to buy expensive hardware and software. Also major saving was made on the up gradation of software license cost and the workforce. Using the cloud technology has improved the operations by reducing the time required to resolve students and staff technical problems and overall efficiency has seen major improvements. As reinforced by JISC Director of Service Relationship, www.salesforce.com , David Utting, (2017) in the report "Implementation of Cloud Technology and its implication in the Higher Education" that the adoption of cloud technology in the UK HE institutions has seen exponential improvement in efficiency and problem resolution. With benefits he also mentioned number of challenges faced in the adoption of cloud technology for UK HE institutions such as data security and data privacy concerns are on the top of the list. The JISC Director further mentioned that there are serious concerns about storage of data over the public cloud among universities and their staff which needs to be addressed so that the adoption rate in higher education can be increased across U.K.

The cloud technology can be extremely useful technology in order to support big data processing for complex research as it provides computer resources that are based on demand of the end users. In order to meet these demands the Newcastle University in UK has adopted cloud computing technology to support the research projects. The university has more than (20 Million Pound) research projects and it requires processing and transferring of large bulk of data from lab to the cloud to carry out detail analysis. For big data analysis the cloud

technology provides the platform that can process, analyse the data effectively and support the research that are data intensive. It is evident that cloud computing technology for UK HE institutions with large benefits have some serious challenges that need to be addressed. According to (Kalpeyeva and Mustafina, 2016) the major barrier in the adoption of cloud computing technology in UK HE institutions is due to lack of uniform standard of services provided by the providers. It has becomes a real challenge to select the providers as there is variable standards of service offered by various providers and there is no benchmark or uniform framework of service that is available which can help the selection of the cloud provider. In the following section list of benefits with adoption challenges in the implementation of cloud computing in the U.K HE institutions will be discussed.

4.5.1 List of Benefits and Opportunities

The adoption of cloud computing in U.K HE institutions has enable the institution to meet the ever changing demands of the market and provided an environment where skilled workforce can produced so they can contribute effectively. In the following section the key benefits that were achieved by UK HE institutions due to the adoption of cloud computing technology are explained:

- Due to the adoption of cloud technology the UK HE institutions were able to reduce the infrastructure cost and operational cost by moving towards a centralized management framework. The UK institutions were able to experience very fast processing and high bandwidth speeds. The cloud computing platform provided the educational institutions to process large quantity of data sets that was not possible with the traditional platforms. This allowed UK HE institutions to carry out latest research and have an edge over their competitors (Kalpeyeva and Mustafina, 2016);
- As the UK HE institutions were facing reduced public budget for education due to the economic constraints the use of technology help to reduce the initial capital and operational expenses. Also the technology enable the educational institution to use the resources effectively when required by using scalability. The cloud technology provides a scalable solution where the resources are provisioned based on the demand of the end user automatically and de-provisioned when the requirements are reduced. This mechanism ensures that all resources are utilized at the maximum and no resources are wasted (Marinela and Anca, 2016). Also UK HE institutions by using

private cloud are experiencing very high performance as they have dedicated connection for transferring of data and avoid using the public network for the data transfer;

- The UK HE institutions are overwhelming using VLEs (Virtual Learning Environment). As reinforced by Weller in a survey for the Institute of Education Technology 2014 www.hefce.ac.uk , 86% of respondents confirmed the use of VLE in the HE institutions across the country. These virtual platform allow students and staff to work in collaboration and by sharing resources. According to Dong et al. (2016), the UK HE institutions are facing pressures from all quarters and results of this is the changing requirements of the VLEs (Virtual Learning Environment). These e-learning environment hosts educational resources that provides easy access of the material. The author further explains that the use of cloud technology can provide a dynamic environment that is scalable and provide resources according to the demands of the users using the e-learning environment. With the use of cloud technology to support e-learning environment it supports the mobile users who wants to access resources while on the move and communicate with their peers wherever they are and whenever they want. The use of cloud technology has reduce the setup and maintenance cost for e-learning environment and allow the staff working at the UK HE institutions to focus on the front line jobs such as research, teaching and learning and innovation rather than worrying about the system configuration, logistic problems, implementation issues and maintenance strategies (Douglass et al, 2012). It was evident from UK HE institutions where cloud technology was used the staff for these educational establishment were able to support their students well by using more innovation and produce world class research that was able to enrich the learning environment for all the stakeholders. The use of cloud technology also enable UK HE institutions to start any project with minimum delay in the start time with minimal resources required which is helping to initiate many new researches;
- The use of cloud technology in the UK HE institutions have provided nearly the permanence of data where students and staff can store their data on the cloud which will be saved and can be accessible all the time regardless of the end users locations. With the adoption of cloud technology the HE institutions are saving a large amount of money and time in-terms of data storage requirements (Rady, 2015). The technology has enabled the institutions not to backup data themselves as it is the

responsibility of the cloud provider. The author explains that the processing power of the cloud platform is exceptional with comprehensive crash recovery mechanism that reduced any chance of losing data that belongs to students and staff at HE institutions. The technology offers instant backup replacement with the use of virtualization if one of the server breaks down. The technology in the UK HE institutions is providing an enrich learning environment for staff, researchers and student.

4.5.2 List of Challenges and Problems

The use of cloud computing technology with its benefits have some serious challenges for the UK HE institutions which are as follows:

- The UK HE institutions who have adopted to the cloud technology share one of the major concerns regarding the lack of uniform standards or nonexistence of minimum benchmark for level of services across the industry to provide an effective, uniform and reliable service to the cloud users. As the cloud computing is gaining popularity organizations such as UK HE institutions are having problems to adopt the service due to lack of minimum service level framework which can act as a benchmark in the selection of the cloud provider and provide (QOS) Quality of Services according to the educational institutional expectations (Rauh and Prince, 2017). The HE institutions reported that due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the industry there are serious concerns raised recently in security and data privacy breaches, authentication and authorization, lack of third party audit and identity management, integrity and variable availability standards, confidentiality and no uniform incident response and monitoring standards. The lack of a framework to provide quality of service across the industry is considered as a major barrier to the adoption of cloud computing technology;
- The next major barrier in the adoption of cloud technology in the UK HE institutions was the lack of interoperability where legacy applications cannot work with the cloud platform. The cloud platform cannot cater the needs of these legacy system and in many cases the UK HE institutions has spent more time, money and manpower to adapt and change the legacy applications to meet the requirements of the cloud platform;

- The next major problem that UK HE institutions are facing is the variable standards in terms of security and privacy issues of the data that is stored on data centres where the students and staff have no access to the third party servers (Holzinger, Röcker, and Ziefle, 2015). There are serious concerns from students, staff and researchers in the UK HE institutions about the security and privacy of the data which can lead to the failure of using the service. Due to lack of security and privacy of data there are challenges related to the confidentiality, integrity, accountability and authenticity of the data which can be very detrimental to the confidence of the cloud users in the UK HE institutions. Also there is a weak control on the provider and there are different security standards that are deployed due to weak uniform standards. This can lead to various types of attacks such as Man-in-the-Middle, DOS (Denial of Service), DDOS (Distributed Denial of Service Attack) which can affect the availability of the service offered by institutions and the whole operations can come to a halt (Amazon Web Service, 2014);
- Various other security concerns were raised by UK HE institutions such as data breaches have taken place in the past, insider attacks due to poor internal control mechanism, data segregation issues in the cloud model and weak or no standards for a quality services are the concerns that are a major hurdle in the smooth operation of the cloud technology.

4.5.3 Case Study Contribution to the Proposed Model: Higher Education and Adoption of Technology Challenges and Changing Scenario Model

The UK HE institutions is facing the same external and internal issues mentioned in the proposed model as detailed above. In the following section different factors from the proposed model that have affected the UK HE institution will be discussed in detail.

- **Government policies and Economic Factor:** Due to the current economic climate and with limited budget for public sector; the U.K HE institution have to change and adapt to these external pressures. The government is driving initiatives which can reduce the public sector expenses, maximize resources and improve the operations in the public sector. All these initiatives are being introduced to have value for money. The government policies is being promoted by the Higher Education Funding Council

for England (HEFCE) by rigorously promoting the drive for the adoption of cloud computing technology in the UK HE institutions. The initiative provides financial and technical supports for all HE institutions to move towards cloud and provides all services to its audience using the shared platform of cloud computing. There is a huge pressure not only in terms of financial constraints in the public sector also huge pressure is being faced in order to incorporate new technology and improve the way the HE institutions perform their daily operations (Hossain et al, 2015). With the adoption of cloud technology staff at UK HE institutions can focus on providing excellent quality of teaching and learning and improving research rather than worrying about buying new hardware, upgrading software license and issues such as purchase and logistic. The government can save a large amount of capital investment and reduced the operating cost by moving towards the cloud computing platform. With the integration of technology and especially cloud computing technology into education the whole sector has been reformed where the initial capital investment required to have and maintained expensive hardware and software is removed. It is more affordable to maintain the operations and provided HE institutions across UK an opportunity to invest the same money in other areas, maintain high quality of research and still operate in the tight budget (Broucker et al, 2017). The use of cloud technology in the HE institutions in UK totally support the government visions, policies and its strategic goals to reduce the cost of operations in the public sector and integrate technology into each education sector to support collaboration, research and better standards of teaching and learning practices.

- **Service Provider Standards and Level of Service Factors:** The next factor that has influence the adoption of cloud technology in the HE institution of UK is the level of services or the quality of service offered by the cloud provider in country. There were serious concerns raised by all the stakeholder in UK HE institutions due to lack of uniform standards, nonexistence of (QoS) Quality of Service offered by the cloud provider and absence of minimum benchmark for level of services provided across the cloud industry in an effective manner to its cloud users. It was evident from the case study that as the cloud computing is gaining popularity the HE institution in UK, different institutions are having problems to adopt the service due to lack of minimum service level framework or poor and variable QoS (Quality of Service) offered by the cloud providers in UK. The standard of service which can act as a benchmark in the

selection of the cloud provider and provide quality of services according to the users expectations is not available among the cloud providers. According to (Cavus and Munyavi, 2016) due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the industry there are serious concerns raised recently due to poor level of standards offered by different cloud providers that is resulting in security and data privacy breaches, authentication and authorization, lack of third party audit and identity management, integrity and variable availability standards, confidentiality and no uniform incident response and monitoring standards.

- **Strategic Goals:** The UK HE institutions are facing a shift towards the cloud technology. The support for HEFCE in 2011, helped established the Joint Information System Committee (JISC) and investment of more than 12.5 (Million pound sterling) to provide a shared cloud platform for conducting latest researches and sharing of educational resources (Hitchcock et al, 2005). The UK HE institutions such as Kent, Exeter, Oxford and many others were the partners in the implementation of cloud based solutions. The involvement of the private sector is very crucial for any initiative to succeed. For the adoption of cloud technology in the UK HE institutions various private sector companies such as Microsoft, Google and Apple started providing cloud based applications to support education (Ismail, 2016). The author further explains that with more competition from the private sector HE institutions in UK are taking advantage to build offsite email system that is without any cost. The University of Westminster has adopted cloud technology that has resulted in the saving of more than (1 Million Pound sterling) for the university as they do not need to buy expensive hardware and software. Also major saving was made on the up gradation of software license cost and the workforce. Using the cloud technology has improved the operations by reducing the time required to resolve students and staff technical problems and overall efficiency has seen major improvements. As reinforced by JISC Director of Service Relationship, http://www.hefce.ac.uk**,** David Utting, 2017 in the report "Implementation of Cloud Technology and its implication in the Higher Education" that the adoption of cloud technology in the UK HE institutions has seen exponential improvement in efficiency and problem resolution. The strategic direction is very clear and the government is investing heavily to promote the initiative to implement cloud computing platform in the U.K HE institutions. With benefits he also mentioned number of challenges faced in the adoption of cloud technology for

UK HE institutions such as data security and data privacy concerns are on the top of the list. The JISC Director further mentioned that there are serious concerns about storage of data over the public cloud among universities and their staff which needs to be addressed so that the adoption rate in higher education can be increased across U.K.

- **Data Security, Data Privacy and Legal Factors:** In U.K data security, data privacy and legal issues have major implications for any organization. According to the Data Protection Act 1998, UK, the law provides safeguards to protect individuals' personal information and its privacy. The law details who is allowed to access the personal information and also divides quickly the responsibility to all stakeholders for the protection and security of data. The personal information should be accurate and used fairly and the access to the personal information has to be limited by only authorized users. The factors such as data security, data privacy, confidentiality, availability and legal implication and compliance has major influence in the decision of adopting a cloud technology in the UK HE institutions. This is the most critical area as any breach in the data security and privacy will have serious legal implications according to the data protection laws in UK for the HE institutions and all stakeholders involved. The concerns that were raised by some stakeholders in the HE institutions was the risk of losing data or network breach that can result in the loss of confidentiality, integrity and availability of data if the decision is made to move towards cloud computing platform. The concerns related to storing of the data on a third party server that will have a lack of control over the data and if the providers fails to separate the resources this could lead to serious security risks. At the same time legislation on data protection can have serious obligations and consequences for the HE institutions in UK if there is data security or privacy breach by storing data over the cloud provider. The situation even becomes worst in the absence of a uniform standard of service framework which can evaluate, assess and make the cloud providers accountable to the level of service offered. These factors are also influencing the adoption decision for cloud computing in the HE institutions in UK.
- **Management and Staff Perception and Acceptance:** The next factor that has influence the adoption of cloud technology in the HE institution of UK is the acceptance of management and staff to adopt the cloud technology and their perceptions related to this new technology. The HE institutions in UK faced a barrier

from some quarters in the management and staff who were worried with the adoption of cloud technology in HE institutions due to data security and privacy challenges. The perception of all stakeholder who want to use the technology must be considered and addressed before the adoption of cloud technology in any environment.

- **Organizational and Cultural Factors:** The next factor that is influencing the adoption of cloud technology in the UK HE institution is the organizational and cultural issues. The HE institutions just like any other organization has to address the fear and resistance to the change in the organization. According to Booz Allen Hamilton, a leading consultancy service organization in management and technology identifies that with the traditional change in the information technology; the support by training only is not adequate anymore. The stakeholders in the HE institution during the adoption of cloud technology will have their concerns and see the overwhelming impact on the entire organization and its way of working due to this new technology. The approach of 'one size fits all' is not a good solution to the change process and can create barriers in the adoption of cloud technology (Mehmet and Serhat, 2011). As cloud technology will impact the organizational and cultural of the UK HE institutions this factor has to be considered while the adoption of cloud technology. Proper support mechanism should be in place to ensure a smooth transition from the traditional platform to the cloud based solution.
- **Technological Factors:** The move towards cloud technology there will be no need to acquire new infrastructure and all IT maintenance will be carried out by the third party provider which will result in saving a large amount of capital and time. The technology will ensure monitoring the performance of all HE institutions from a central location. There was a requirement from various sectors of the population to reduce the electricity consumption and move toward green computing. The move towards cloud technology by the HE institutions in UK will help efficient use of key resources and promoted energy saving mechanism. With improve resource utilization and saving energy consumption there are various technological challenges in the adoption of cloud technology such as resource exhaustion, lack of standard of services, not predictable level of performance offered. Also, issues such as data transfer bottleneck and data lock-in uses need to be addressed.
- **Competitor Influence Factor:** Similar to any other HE institutions across the world the UK HE institutions are facing enormous pressures from their competitors in the

education sector to provide quality of teaching and learning facilities. The demand on HE institutions is to support latest research such as processing big data for producing new medicines or any other latest development in the field of science and technology, improve teaching and learning facilities by providing more interaction and support the new learning style of the students who want to access any information on the move and remain connected regardless of their location. These new trends can only be supported by the use of cloud computing technology platform that can provide a rich learning environment for the researchers, students and staff at HE institutions in the country. All HE institutions in UK are trying to provide these facilities to their students and there is a huge competition in the education sector that is influencing the move towards the cloud computing technology.

4.6 Case Study: Cloud computing model for Indian Higher Education

The cloud computing is growing at a very fast rate across the world and HE institutions in India is also experiencing the changes due to a very high adoption rate. The government can easily see that with the adoption of cloud technology they can save a large amount of money and manage all the operations of the HE institutions that are spread across the country in an effective manner. The Maharashtra government in India, is planning to implement an e-government solution to coordinate between various government offices and HE institutions and this is only possible with the implementation of the cloud delivery platform. There are large cloud vendors who are taking keen interest in working with Indian HE institutions by designing and implementing educational programs specially designed for delivering interactive lessons (Sakr, 2014). Vendors such as Microsoft have introduced programs such as Live@edu, whereas Google Apps provides an educational platform to learn and share resources in an interactive manner. The Google Docs has introduced a large suite in the Indian HE institutions by offering Google Docs that allow students and staff to share and compile documents online. The package also provides lot of other features for students and staff working at the HE institution by providing email service, assistance to manage the classrooms and shared storage area and web development tools. The IBM introduced Cloud Academy in the Indian HE institutions that is allowing students to learn in an interactive manner. The use of cloud technology in the Indian HE institutions is allowing all educational institutions to coordinate with each other to improve the learning experience and share resources (Sujit, 2016).

4.6.1 List of Benefits and Opportunities

The benefits of implementation of cloud computing technology in the Indian HE institutions are as follows:

- India being a very large country with HE institutions spread across the country. The need to improve these HE institutions can only be possible with the implementation of cloud computing technology. The HE institutions in the country has adapted to the new changes in the educational sector by providing online resources using cloud computing technology as a platform. The use of cloud technology has enabled far better processing ability, provides guarantee with exceptional high up-time, processing ability and supporting large amount of students and staff to interact with each other regardless of their location to contribute in the latest research and development in the HE institution (Sakr, 2014);
- With the use of Cloud computing technology the government can easily monitor and manage all HE institutions across the country that was not possible without a centralized management system;
- Due to the adoption of cloud technology the Indian HE institutions were able to reduce the infrastructure cost and operational cost by moving towards a centralized management framework. The HE institutions were able to experience very fast processing and high bandwidth speeds that enable the latest research and development and ensure a rich learning environment for students across the educational institution in the country. The cloud computing platform provided the educational institutions to process large quantity of data sets that was not possible with the traditional platforms (Alabbadi, 2016);
- The use of cloud computing in the HE institutions can provide educational network that can be shared by all students across the country. This will provide an opportunity to produce knowledgeable individuals who can contribute to the economy effectively;
- The implementation of HE cloud across all the universities in the country provides equal resources, material and streamline the processes. By implementing the same procedures and processes it will ensure the same standards across all the HE institutions in the country regardless of their location. This will improve the standard of teaching, learning and research across the country;

- The use of educational cloud has reduced the cost of licensing new software. Using the traditional model a large amount of budget was spent in acquiring various licenses (Saleh and Shahzad, 2016). By using the educational cloud in HE institutions the cost of licensing is not required. The library and research activities can built e-learning portals which can allow sharing of all resources and applications without the cost of acquiring individual licenses for each university which can save a large amount of money that can be used in research or improving front line services and facilities for students.

4.6.2 List of Challenges and Problems

The list of challenges and problems to deal with, are the following:

- The Indian HE institutions who have adopted to the cloud technology share one of the major concerns regarding the lack of uniform standards or nonexistence of minimum benchmark for level of services across the industry to provide an effective, uniform and reliable service to the cloud users. This is creating a major barrier in the adoption of the cloud services due to lack of uniform standards and the level of services offered (Kalpeyeva and Mustafina, 2016):

- India is a third world country and it is still progressing and making socio economic development. The major hurdle that is faced in the implementation and the use of cloud computing is the variable standards, speed and connectivity issues related to Internet across the country. Just like any other third world country; India is facing the same problem of different Internet connection speeds across the country. In India the standards for Internet speed is not consistent between the major cities and other rural areas. Some universities due to their location cannot be connected to the cloud or the speed of the Internet is a major barrier to take full advantage of the cloud computing. In order to take full advantage of the cloud computing all HE institutions regardless of their location should be able to access high speed Internet access. With only consistent high-speed Internet access the HE institutions will be able to take full advantage of cloud technology by storing and accessing data quickly.

4.6.3 Case Study Contribution to the Proposed Model: Higher Education and Adoption of Technology Challenges and Changing Scenario Model

The Indian HE institutions is facing the same external and internal factors mentioned in the proposed model as detailed above, as discussed for Higher Education and Adoption of Technology Challenges and Changing Scenario Model. In the following section different factors from the proposed model that have affected the Indian HE institution will be discussed in detail.

- **Service Provider Standards and Level of Service Factors:** The next factor that has influence the adoption of cloud technology in the HE institution of India is the level of services or the quality of service offered by the cloud provider in country. There were serious concerns raised by all the stakeholder in the HE institutions due to lack of uniform standards, nonexistence of (QoS) Quality of Service offered by the cloud provider and of absence of minimum benchmark for level of services across the industry to provide an effective, uniform and reliable service to all the cloud users (Bilal et al, 2017). Due to lack of Quality of Service framework and providers offering different standard of service across different cities it is a major barrier in the adoption of cloud computing service for HE institutions that are located in under developed cities in India according to the author. As the cloud computing is gaining popularity; the HE institution in India are having problems to adopt the service due to lack of minimum service level framework or poor and variable QoS (Quality of Service) offered by the cloud providers in the country. The standard of service which can act as a benchmark in the selection of the cloud provider and provide quality of services according to the users expectations is not available among the cloud providers. Due to this there is poor level of standards offered by different cloud providers that is resulting in security and data privacy breaches, authentication and authorization problems, lack of third party audit and identity management issues, integrity and variable availability standards, confidentiality and no uniform incident response and monitoring standards (Kumar and Hsiang, 2017).
- **Government policies and Economic Factor:** The India government can easily see that with the adoption of cloud technology they can save a large amount of money and manage all the operations of the HE institutions that are spread across the country in an effective manner. The government policies and economic factor needs a detailed consideration in the adoption of cloud computing technology for HE institution in

India (Manvi and Shyam, 2015). The government is planning to implement an e-government solution to coordinate between various government offices and HE institutions and this is only possible with the implementation of the cloud delivery platform. There are large cloud vendors who are taking keen interest in working with Indian HE institutions by designing and implementing educational programs specially designed for delivering interactive lessons. The government can save a large amount of capital investment and reduced the operating cost by moving towards the cloud computing platform. With the integration of technology and especially cloud computing technology into education the whole sector has been reformed where the initial capital investment required to have and maintained expensive hardware and software is removed.

- **Technological Factors:** The move towards cloud technology there will be no need to acquire new infrastructure and all IT maintenance will be carried out by the third party provider which will result in saving a large amount of capital and time. The technology will ensure monitoring the performance of all HE institutions from a central location (Bayya, 2009). There was a requirement from various sectors of the population to reduce the electricity consumption and move toward green computing. The move towards cloud technology by the HE institutions in India will help efficient use of key resources and promoted energy saving mechanism. With improve resource utilization and saving energy consumption there are various technological challenges in the adoption of cloud technology such as resource exhaustion, lack of standard of services, not predictable level of performance, issues such as data transfer bottleneck and data lock-in uses that need to be addressed (Hussain and Abdulsalam, 2014).
- **Competitor Influence Factor:** Similar to any other HE institutions across the world the India HE institutions are facing enormous pressures from their competitors in the education sector to provide quality of teaching and learning facilities. The demand on HE institutions is to support latest research such as processing big data for producing new medicines or any other latest development in the field of science and technology, improve teaching and learning facilities by providing more interaction and support the preferred learning styles of the students who want to access any information on the move and remain connected regardless of their location. (Hussain and Abdulsalam, 2014). These new trends can only be supported by the use of cloud computing technology platform that can provide a rich learning environment for the researchers,

students and staff at HE institutions in the country. All HE institutions in India are trying to provide these facilities to their students and there is a huge competition in the education sector that is influencing the move towards the cloud computing technology.

4.7 Case Study: Cloud computing model for US Higher Education

There are many HE institutions across the world that are adopting the use of cloud computing technology to meet the ever changing requirements of the market. The HE institution in US are leading the way to acquire the technology as it provides advantages such as mobility, scalability, availability and the requirement to of the capital cost is not anymore the most relevant. The technology is becoming popular across the US HE institutions and the government is ready to provide investment to introduce this new initiative in the education sector. Mostly the HE institutions in the country have designed their own private clouds where students and staff can easily share their resources and support teaching and learning activities. The community colleges across US are adopting the use of technology as it is cost effective approach for these colleges as they design their own Virtual Learning Environment (VLE) to support their student's needs as majority of them need a mobile supportive system that can help them to access resources while they are on the move (Thomas, 2011). The North Caroline State University (NCSU) is an example of HE institution that is using a cloud technology to support a Virtual Learning Environment (VLE). The use of the technology was based on the economic and usability factor but at the same time there should be cohesion between the control of data and economy of scale that has to be considered.

4.7.1 List of Benefits and Opportunities

The benefits of implementation of cloud computing technology in the US HE institutions are as follows:

- One of the advantage of using cloud computing technology is to promote the idea of low cost education across the HE institution in the US. Like any other western economies, the US economy is also facing a bleak situation with less budget allocation for the public sector. The use of cloud computing technology in the HE institutions across the country provide quality education at a very reduce cost. With

the current financial constraints and economic condition it is not justifiable to have the traditional data centre to process data as it is very costly (Taylor and Hunsinger, 2011);

- The use of cloud technology in US HE institutions has resulted in the improvement of efficiencies and services across the educational institution such as student services, HR Personnel, Research and all other departments has seen a huge improvement. The utilization of resources has increased and (QoS) quality of service provided to various stakeholders has improved (Siegle, 2010);
- The use of cloud computing in the US HE institutions has provide educational network that can be shared by all students across the country. This will provide an opportunity to produce knowledgeable individuals who can contribute to the economy effectively;
- The implementation of HE cloud across all the universities in the country provides equal resources, material and streamline the processes. By implementing the same procedures and processes it will ensure the same standards across all the HE institutions in the country. This will improve the standard of teaching, learning and research across the platform.

4.7.2 List of Challenges and Problems

The US HE institutions who have adopted to the cloud technology share one of the major concerns regarding the lack of uniform standards or nonexistence of minimum benchmark for level of services offered by the cloud providers across the industry to provide an effective, uniform and reliable service to the cloud users. The HE institutions reported that due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the industry there are serious concerns raised recently in security and data privacy breaches, authentication and authorization, lack of third party audit and identity management, integrity and variable availability standards, confidentiality and no uniform incident response and monitoring standards (Stankov, Miroshnychenko and Kurbel, 2015). The lack of a framework that can allow cloud users to easily select the provider, evaluate and make the provider accountable for their quality of service is considered as a major barrier to the adoption of cloud computing technology in the US HE institutions according to the authors.

The next major barrier in the adoption of cloud technology in the US HE institutions was the lack of interoperability where legacy applications cannot work with the cloud platform. The cloud platform cannot cater the needs of these legacy system and in many cases the HE institutions has spent more time, money and manpower to adapt and change the legacy applications to meet the requirements of the cloud platform (Siegle, 2010). The US HE institutions are facing is the variable standards in terms of security and privacy issues of the data that is stored on data centres where the students and staff have no access to the third party servers (Holzinger, Röcker and Ziefle, 2015). There are serious concerns from students, staff and researchers in the HE institutions about the security and privacy of the data which can lead to the failure of using the service.

4.7.3 Case Study Contribution to the Proposed Model: Higher Education and Adoption of Technology Challenges and Changing Scenario Model

The US HE institutions is facing the same external and internal issues mentioned in the proposed model as detailed above concerning Higher Education and Adoption of Technology Challenges and Changing Scenario Model. In the following section different factors from the proposed model that have affected the US HE institution will be discussed in detail.

- **Government policies and Economic Factor:** Due to the current economic climate and with limited budget for public sector; the US HE institution have to change and adapt to these external pressures. The government is driving initiatives which can reduce the public sector expenses, maximize resources and improve the operations in the public sector. All these initiatives are being introduced to have value for money. There is a huge pressure not only in terms of financial constraints in the public sector also huge pressure is being faced in order to incorporate new technology and improve the way the HE institutions perform their daily operations. The government can save a large amount of capital investment and reduced the operating cost by moving towards the cloud computing platform in the US HE institution. These factors can influence the decision in the adoption of cloud technology in the HE institutions.
- **Service Provider Standards and Level of Service Factors:** The next factor that has influence the adoption of cloud technology in the HE institution of U.S is the level of services or the quality of service offered by the cloud provider in country. There were serious concerns raised by all the stakeholder in the HE institutions due to lack of uniform

standards, nonexistence of (QoS) Quality of Service offered by the cloud provider. The absence of a minimum benchmark for level of services across the cloud industry to provide an effective, uniform and reliable service is major barrier to the adoption of cloud technology in the US HE institutions. As the cloud computing is gaining popularity the HE institution in U.S are having problems to adopt the service due to lack of minimum service level framework or poor and variable QoS (Quality of Service) offered by the cloud providers across U.S. The standard of service which can act as a benchmark in the selection of the cloud provider and provide quality of services according to the users expectations is not available among the cloud providers. Due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the industry there are serious concerns raised recently due to poor level of standards offered by different cloud providers that is resulting in security and data privacy breaches, authentication and authorization issues, lack of third party audit and identity management problems, integrity and variable availability standards, confidentiality and no uniform incident response and monitoring standards.

- **Data Security, Data Privacy and Legal Factors:** In U.S data security, data privacy and legal issues have major implications for any organization. The data protection legislation provides safeguards to protect individuals' personal information and its privacy. The law details who is allowed to access the personal information and also divides quickly the responsibility to all stakeholders for the protection and security of data. The personal information should be accurate and used fairly and the access to the personal information has to be limited to only authorized users. The factors such as data security, data privacy and legal implication for data privacy is having a major influence in the decision of adopting a cloud technology in the US HE institutions. This is the most critical area as any breach in the data security and privacy will have serious legal implications according to the data protection laws in US for the HE institutions and all stakeholders involved. The concerns that were raised by some stakeholders in the HE institutions was the risk of losing data or network breach that can result in the loss of confidentiality, integrity and availability of data if the decision is made to move towards cloud computing platform. The concerns related to storing of the data on a third party server that will have a lack of control over the data and if the providers fails to separate the resources this could lead to serious security risks. At the same time legislation on data protection can have serious obligations and consequences for the HE institutions in US if there is data security or

privacy breach by storing data over the cloud provider. Also the situation becomes more critical due to the absence of a quality framework that is agreed by all stakeholders in the cloud industry to provide a uniform guarantee to the quality of service offered. Data protections, its privacy, confidentiality and availability to authorized persons only are issues that are influencing the adoption decision for cloud computing in the HE institutions in US.

- **Organizational and Cultural Factors:** The next factor that is influencing the adoption of cloud technology in the US HE institution is the organizational and cultural issues. The HE institutions just like any other organization has to address the fear and resistance to the change in the organization. As cloud technology will impact the organizational and cultural of the US HE institutions this factor has to be considered while the adoption of cloud technology. Proper support mechanism should be in-place to ensure a smooth transition from the traditional platform to the cloud based solution.
- **Technological Factors:** The move towards cloud technology there will be no need to acquire new infrastructure and all IT maintenance will be carried out by the third party provider which will result in saving a large amount of capital and time. The move towards cloud technology by the HE institutions in US will help efficient use of key resources and promoted energy saving mechanism. With improve resource utilization and saving energy consumption there are various technological challenges in the adoption of cloud technology such as resource exhaustion, lack of standard of services, not predictable level of performance, issues such as data transfer bottleneck and data lock-in uses that need to be addressed.
- **Competitor Influence Factor:** Similar to any other HE institutions across the world the US HE institutions are facing enormous pressures from their competitors in the education sector to provide quality of teaching and learning facilities. The demand on HE institutions is to support latest research such as processing big data for producing new medicines or any other latest development in the field of science and technology, improve teaching and learning facilities by providing more interaction and support the new learning style of the students who want to access any information on the move and remain connected regardless of their location. These new trends can only be supported by the use of cloud computing technology platform that can provide a rich learning environment for the researchers, students and staff at HE institutions in the country. All HE institutions in U.S are trying to provide these facilities to their students and there is a huge competition

in the education sector that is influencing the move towards the cloud computing technology.

- **Strategic Goals:** In order to achieve the strategic goals of the organization it is an important factor to integrate the use of cloud technology in the HE institutions across US. The use the cloud technology has improved the operations by reducing the time required to resolve students and staff technical problems and overall efficiency has seen major improvements. The strategic direction is very clear and the government is investing heavily to promote the initiative to implement cloud computing platform in the US HE institutions.
- **Management and Staff Perception and Acceptance:** The next factor that has influence the adoption of cloud technology in the HE institution of US is the acceptance of Management and Staff to adopt the cloud technology and their perceptions related to this new technology. The HE institutions in US faced a barrier from some quarters in the management and staff who were worried with the adoption of cloud technology in HE institutions due to data security and privacy challenges. The perception of all stakeholder who want to use the technology must be considered and addressed before the adoption of cloud technology in any environment.

4.8 Summary

In the chapter of the study the research explains the cloud usage in different sectors and its application. The chapters also highlight the adoption of cloud computing in higher education and what are their main end user groups that are using cloud services. The chapters provides detail insight into the cloud architecture and various deployment models used by the HE institutions. The chapter discusses the cloud adoption benefits and challenges faced by HE institutions. The study examines four case studies of various HE institutions across the world and examine the implementation benefits and challenges in these case studies.

CHAPTER 5. Requirement of Minimum Service Level Framework

5.1 Introduction

In the last many years, the computation has experienced enormous changes from centralized to distributed system and now is moving back to the centralization as a structure (Mell and Grance, 2011). Cloud computing is an emerging disruptive technology that supports the rapid growth of data which we experienced in this Internet age as the capacity of normal PC cannot meet the demands of large-scale massive data scientific computing (Baranwal and Vidyarthi, 2016). The technology is experiencing massive growth in terms of new users and to match the demand of a sector who has huge investments as reported by a report publish by Forbes, www.forbes.com (2016), 'Roundup of Cloud Computing Forecasts and Market Estimates', that states that the worldwide spending in the public cloud services will grow from 19.4% of compound annual growth rate (CAGR) from $70B in 2015 to more than $141B by 2019. The model with its benefits have many concerns which have been raised. This model leaves the client/customer not aware of where the data is stored or how it is maintained. Due to the design of the model, the client or customer has lack of or no control over their data and where Internet is used as a communication media to access data, which raises serious concerns regarding the data availability (Arjun and Vinay, 2016). The security and privacy of the data in the cloud computing is a major concern and consider as a major barrier in the adoption of the technology, where the provider has to provide concrete assurance in Service Level Agreement (SLA) to assure the customer regarding the data protection and privacy issues (Eisa et al, 2016). The report published by KPMG, www.kpmg.com , '*How to Manage 5 Key Risks in Cloud Computing'*, 2016, reinforces cloud users major concerns such as data loss, concerns related to the security, confidentiality, integrity and privacy of data.

There is a lack of clarity in terms of regulatory laws to protect data and intellectual property, and this is due to lack of uniformity in terms of Quality of Service (QoS) and standards offered by various cloud providers which is the major barrier in the adoption of cloud technology according to (Dong et al, 2016). With the implementation of General Data Protection Regulation (GDPR) in the near future, there will be serious implications for the cloud providers and its consumers due to lack of uniformity and variable standards of service offered by various cloud providers according to the press release of the EU Commission on data protection reform 2016. It is not possible to fulfill all the customers' expectations where

service providers are offering different quality of service and there is no uniform framework or a benchmark to measure the QoS offered by various cloud providers as mentioned by the report. There is a major requirement to have a framework that will assist to evaluate the services offered by the cloud providers, and also that addresses cloud users concerns and provide a mechanism to measure the QoS offered by the cloud providers. The current research tries to fill this gap by proposing a MSL (Minimum Service Level) model for case study which is HE (Higher Education) institution to help choosing the cloud licensing system that best fits a given organization needs. The proposed model will remove any confusion for the cloud users and enable them to differentiate and select the cloud provider using the proposed model as it defines the minimum standards, taking the right sets of key parameters that cloud providers must follow and held accountable to this model.

The proposed model will set a minimum standard or benchmark for the quality of services offered, provide set criteria which will ease the selection of the cloud provider regardless of their hosting location. The proposed model will address security concerns in-terms of CIA Triad (Confidentiality, Integrity, and Availability), provide uniformity in terms of service delivery which will improve the overall adoption rate for cloud computing technology. In the following section of the chapter initially a detailed literature review will be provided by discussing the serious concerns due to lack of minimum framework and variable set of service level agreements provided by the cloud providers. Different security challenges due to the absence of uniform service level framework in the cloud technology will be discussed such as notorious 9 threats, CIA triad issues, and the implication of GDPR on the cloud computing industry and green SLA requirements.

5.2 Set the Context: A Brief Literature Review

The cloud computing model significantly cut the IT infrastructure costs by providing on-demand access to vast IT resources that are available in the cloud. In order to meet the expectations of the cloud users, SLA is crucial as it defines a contract which details precisely the level of service that a cloud provider will offer. Before adopting a cloud computing technology, the contract detailing SLA need to be discussed and agreed by all the concern parties. There is a lack of uniformity in-terms of (QoS) and standards which is due to poor designed SLAs offered by various cloud providers. The cloud industry has failed so far to produce a universal agreed SLAs framework, which is considered as a major barrier to the

adoption of cloud technology. Due to confusion and absence of universal agreed framework or a minimum quality of service standards, different level of services is being provided by cloud providers. Due to the absence of a framework, the potential cloud users cannot select the provider, evaluate their performance against a universally agreed benchmark of set standards and make the service provider accountable for the level of service offered. Due to the absence of a uniform service level framework the cloud data centre can fail as they consist of various components which can malfunction and affect the entire performance of the system e.g. failure of a physical server, network, or a virtual machine (VM) can degrade the performance (Radha et al, 2015). This is a violation of SLA between cloud provider and users (Wagle, 2017) that was signed between the cloud provider and users. Due to the absence of the uniform service level framework different providers deal with the violations in a different manner. There is a debate that under these circumstances the cloud service provider should pay to the cloud customers for each violation but due to the absence of the uniform framework there is no set standards which cloud providers have to follow as mentioned by (Khaitan and McCalley, 2015).

The main purpose of SLAs is to provide concrete guarantees to the cloud customers to offer a good level of service which will ensure if anything goes wrong the provider will be responsible for any disruption (Mosallanejad et al, 2016). The author further explains the problematic area is the QoS detailed on the SLA document, as there is no mechanism to verify the level of service delivered or not? SLA consist of two main metrics which are uptime metric detailing the guarantees to the access of the services whereas second metric related to response time which states the quality of services being offered. Different cloud providers offer different level of services, which cannot be verified and there is no uniformity or a framework to make the providers accountable which creates confusion and poor QoS delivered to the cloud users according to (More, Vij and Mukhopadhyay, 2017). For cloud users it is impossible to verify the level of service offered, to evaluate the level of service offered, and make providers accountable. There should be a mechanism or a framework which allows the cloud users to verify each metrics and make the cloud providers accountable for the level of services offered (Beloglazov, Abawajy, and Buyya, 2016). With numerous benefits to cloud technology there are serious challenges related to the lack of uniformity in terms of QoS and standards offered by various providers. This is due to poorly define SLAs or not meeting the set parameters of various SLAs which are resulting in poor QoS and

considered as a major barrier in the adoption of the cloud computing technology. Different level of services provided and no uniform performance model; there is no performance criteria to measure, evaluate, and benchmark the level of services offered by these cloud providers and that is badly affecting the cloud adoption rate. With the implementation of General Data Protection Regulation (GDPR) in the near future there will be serious implications for the cloud providers and its consumers due to lack of uniformity and variable standards of service offered by various cloud providers (Stankov, Miroshnychenko and Kurbel, 2015). In the next section of the study, due to absence of framework or a mechanism to measure the performance of cloud provider there are major issues and challenges to the adoption of cloud computing technology will be discussed.

5.3 Issues and problems due to lack of uniform model

5.3.1 Cloud Data Centre Failures Issues

Due to lack of uniformity or absence of uniform model in terms of agreed SLAs there are serious challenges related to the failures of cloud data centres. These data centres can fail to operate due to any technical glitch. There is lack of clarity in terms of SLAs, defining the consequences of data centre failure as there is no uniform model or framework that can acts as a benchmark to measure and evaluate the level of service offered by various cloud providers (Rady, 2015). According to different proposed solutions such as work by (Bilal et al, 2017), provides assurance of SLA compliance and introduced redundancy to eliminate the single point of failure in the cloud data centre. The author explains that in order to fulfil the SLAs the proposed work introduces data replication by using data mapping to prevent data losing in the cloud computing. The proposed work incorporates redundancy and replication to mitigate failures that may happen in the cloud data centres which host cloud provider services. This will ensure that there is no violation of SLAs and provides uniformity. Due to absence of framework there is no universally agreed model that can remove adoption barrier, provide a uniform response and address the concerns of the potential cloud users.

5.3.2 E-Commerce Cloud-Loss of Control

The e-commerce cloud can be very useful to quickly build websites and reduce the cost of building or maintaining the websites. Due to lack of uniform service level framework that can set safeguard through universally agreed SLAs to ensure data confidentiality and provide a

mechanism to have data control there are risks associated with the confidentiality of the data which is stored over cloud. There is a serious concern by end-users about the confidentiality of data that is stored over the cloud as mentioned by (Zhu et al, 2016). Serious issues have been raised in the capability of cloud computing to scale rapidly and store data remotely, where the services are shared among dynamic environment which can be problematic in terms of data privacy assurance issues and maintaining the confidence of the potential users. Outsourcing these services can pose high risk to the cloud users as they lose control over their data couple with lack of clarity in terms of SLA guarantees is a matter of concern for cloud users. The following Table 3, derives the main parameters for e-commerce cloud SLA framework that need to be considered.

Parameters	Description	Citations
Availability	The uptime of the services for the user in specific time	(A. Hossain, et.al, 2012)
Scalability	Ability to increase and decrease the storage space	(Doelitzscher, F, et.al, 2013)
Portability	The services working on different devices or different platforms	(Fogel R, 2016)
Performance	The duration of time to respond on user's request	(Golamdin Abd, 2016)
Security	The security of user data and the safety of the environment in the cloud	(Hsu P et.al, 2014)
Reliability	Services ability to operate over the time without failure	(Helmy Y et al, 2016)
Usability	The ability of the service to be attractive, understandable, learnable, operable	(Ismail, N, 2016)
Backup and Recovery	How the service store the image of user data and the ability to recover data in disaster	(Mircea, M et al, 2011)

Table 3: E-commerce cloud SLA framework

5.3.3 Data Confidentiality and Privacy Concerns

The cloud technology enables businesses to store information in cloud, e-commerce businesses will have a very difficult time to supervise and monitor user's business sensitive information. Using the virtualization techniques, it becomes impossible to find the location of stored data (Yang et al, 2016). Privacy is another major concern in the cloud computing where the design of the cloud infrastructure makes it difficult for cloud users where the current data is stored leading to privacy and protection issues. This is due to the transnational nature of cloud computing that has to face the national regulation privacy according to the author. The existing cloud service level contracts or existing cloud service provider models and not taking sufficient attention on cloud' users privacy and many cases have been reported of consumers poorly informed about the privacy issues according to (Baset, 2016). The study carried by European Network and Information Security Agency, www.enisa.europa.eu , (ENISA, 2017) acronyms, tried to investigate the key issues related to cloud computing security issues. According to the following Table 4, survey conducted more than 70%, of the small and medium size enterprises are concerned in the following six criteria of security issues especially confidentiality issues and the situation is more alarming in the absence of universal agreed framework and cloud service providers mechanism cannot address the following challenges as shown in the table

Criteria	**Very Important**	**Showstopper**	**Total**
Confidentiality of Corporate data	30.9%	63.9%	94.5%
Privacy	43.9%	43.9%	87.8%
Availability of Service and/ or data	47.3%	40.0%	87.3%
Integrity of services and/or data	42.6%	44.4%	87.0%
Loss control of services and/or data	47.2%	28.3%	75.5%
Lack of liability of providers in case of security incidents	43.1%	29.4%	72.5%
Repudiation	47.9%	8.3%	56.2%

Table 4: Security concerns by (ENISA, 2017)

5.3.4 Application Delivery Chain Issues

The cloud based application are working due to a complex and extended delivery chain which involves the components that cross the geographical boundaries and extended across time zones (Ghosh and Ghosh, 2016). The performance of the delivery chain and all components can directly affect the performance and user experiences. According to the research majority of service level agreement offered by the cloud providers are not taking in account the application delivery chain components. A failure in any of these applications in the application delivery chain can lead to major difficulties for cloud users to retrieve their data.

5.3.5 The Cost of Cloud Break Down

The failure of cloud service can happen as we experienced in April, 2011, Amazon www.amazon.com , faced four days of outages in the cloud services which affected millions of users across the world. Various e-commerce companies faced serious financial and reputational damages but this event did not violate Amazon service level agreement because it was not clear in the terms and conditions stated in the SLA. The end users blamed the e-commerce website for this but actually it was a failure at the part of the cloud provider but due to weak SLAs or no universal agreed framework, the cloud provider was not be held accountable for this failure. In the existing literature, some have proposed to maintain the reliability among cloud providers and consumers to include them in the negotiation process. The existing literature proposes (Hofmann and Woods, 2016), a mechanism to manage the SLA in a cloud environment by using the Web Service Level Agreement (WSLA), that will monitor and enforces SLA in a Service Oriented Architecture (SOA). The proposed framework provides a mechanism to manage the requirements of cloud consumers and enforces providers to follow SLAs based on the WSLA specifications that argue to adapt the Services Oriented Architecture. The framework ensures the service quality and reliability standards are met. According to the literature, the problem with the framework is that does not completely support the whole SLA lifecycle. The authors further explains that the framework does not include the negotiation process as it is considered outside the framework which is a major challenge to be addressed. In the next literature (Baraglia, Lucchese, and De, 2015), proposed a framework for cloud SLA management named LoM2His, which is a sunset of FoSII *(*Foundations of Self-governing ICT Infrastructures) project. In this proposed framework the low-level resources metrics map to the High-level SLA parameters. The

model supports the monitoring and enforcement parts of the SLA lifecycle. In the existing literature (Stantchev and Tamm, 2016), SLA attributes are different for various demands. The literature clearly mentions that due to the lack of standardization of SLA and no consistent framework is available to reference it becomes difficult for consumers to compare between the cloud services providers. It becomes a serious challenges for the cloud users to select a providers due to lack consistency in terms of universal service level agreement. According to (Cao et al, 2014), proposes a conceptual platform of SLA in cloud computing that recommends a reputation system for evaluating the reliability and trustworthiness of the provider. The framework proposes a SLA template pool in order to make the SLA negotiation process between cloud providers and cloud consumers more fair and transparent services. The framework allows the cloud provider to advertise their services and consumers can find and select the services which meet their demands. There are practical issues in advertising their services and cloud user selecting these services. The following Table 5 below concludes the existing SLA framework and their components.

Framework & Authors	**Components in SLA Lifecycle**					
	Definition	**Negotiation**	**Deployment**	**Monitoring**	**Management**	**Termination**
Cavus, N. and Munyavi, R (2016)			X	X	X	
P. Manuel. (2016)				X	X	
P. Hofmann and D. Woods. (2016)		X				
Rauh M., Prince J. (2017)		X		X		
Radha. K, Babu, Shaik and Rao. (2015)	X	X	X	X	X	X

Table 5 Components in SLA Lifecycle (Wagle, S. 2017)

There is a need of mechanism to measure the performance of SLA which will improve the overall quality of services offered by the provider (Stewart et al, 2015). According to the existing literature majority of the cloud providers only focuses on a small set of metrics such as availability, request completion rate and response rate. As reinforced by (Beloglazov, Abawajy and Buyya, 2016), a detailed study that breaks down the cloud SLA into easy and understandable metrics to compare SLAs in the cloud provider. The study tries to compare

SLA of Amazon, Rackspace, Microsoft, Terremark vCloud Express and Stomon, and no provider was able to offer a performance guarantee for the services offered. This study also highlighted the fact that no provider has the structure to automatically credit the consumers for SLA violations. The study identifies the problem that unfulfilled expectations are due to the poor choice of parameters. These problems can be addressed with a universal agreed, uniform service level framework that can act as a benchmark to set standards for all the cloud providers.

5.3.6 Security and Transparency Challenges

The security and transparency are considered as the main requirements for cloud service providers (CSPs). A cloud SLA is a documented agreement between the CSP and the Customer that identifies cloud services and service level objectives (SLOs), which are the targets for service levels that the CSP agrees to meet. If a SLO defined in the cloud SLA is not met, the cloud customer may request a remedy (e.g., financial compensation). If the SLOs cannot be (quantitatively) evaluated, then it is not possible for customers or CSPs to assess if the agreed SLA is being fulfilled. This is particularly critical in the case of secSLAs, but it is also an open challenge on how to define useful (and quantifiable) security SLOs? Due to lack of assurance and transparency coupled with security issues result in cloud customers not able to assess the security of the CSP for which they are paying (Zolt and Mann, 2016). This raises two main questions which are how small or medium size business can assess whether CSP can fulfil their security requirements and the second issue is how CSP can provide security assurance to cloud users throughout the cloud service life cycle in the absence of an universal agreed uniform model that can act as a benchmark for all cloud providers regardless of their hosting location. The cloud user require a mechanism and tools that provide them with "good-enough" security in the cloud infrastructure (Martini et al, 2016). Various stakeholders such as ENISA www.enisa.com, 2016, ISO/IEC and European Commission report, 'Cloud Computing and its Implementation Challenges',2016, have proposed various security parameters in service level agreement known as secSLA. The literature proposes security metrics by the introduction of Quantitative Policy Trees (QPT) (Balajipalanisamy et al, 2015) and Quantitative Hierarchical Process (QHP) (Meena et al, 2016), that obtains precise information regarding the security level using the cloud sec-SLAs. According to the literature SLO metrics should contain quantitative and qualitative metrics where boundaries and margins should be set for CSPs. These are the limitation for CSPs to follows. The same security control framework has been proposed by ISO/IEC 27002, the Cloud Security

Alliance Matrix, and the National Institute of Standards and Technology SP 800-53. This mechanism provides an extra layer for security for the end user by providing boundaries and margins as a guideline to the CSPs to abide by them but providers across the industry does not follow the same SLA and they provider offers variable quality of service due to the absence of a universal agreed framework.

5.3.7 CIA Triad Issues

Cloud Computing is an emerging market and its growing at an exponential rate. The adoption process of a cloud provider is a daunting tasks as it entails very complex details in terms of data security and privacy issues that has to be considered by the potential cloud users (Zheng et al, 2016). The author explains as there is no universally agreed framework that acts as a benchmark, the selection process is more complex then proposed multi-objective optimization as it overcomes some of the limitation in the selection of the cloud provider. The provision of Pareto front of optimal solutions creates the selection of the final solution more problematic as data security and privacy concerns are overwhelming. The author explains that for the potential cloud users' data security, data confidentiality, integrity, and availability are serious concerns as reinforced by the Figure 5.1. The particular research is focused only on the security solution rather than having a comprehensive approach to have universal standards for each parameter that are essential in the selection and evaluation of the Quality of Service (QoS) offered by any particular cloud provider regardless of their hosting location.

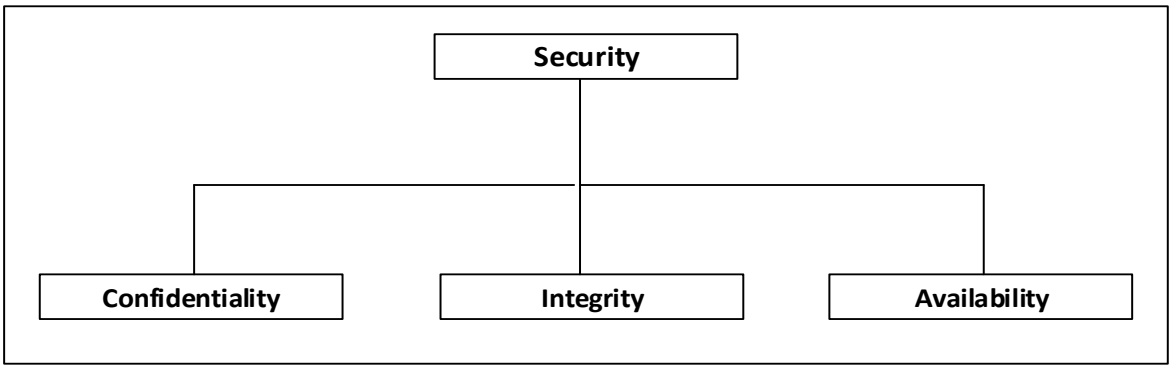


Figure 5.1 Facet of security issues (Alshwaier, A., 2012)

In the existing literature there are proposed models by (Olabiyisi et al, 2016) where the entire selection of the service is according to the consumer's perception and their experiences. Whereas authors have proposed model such as Third Party Auditors (TPA) which is an attempt to address the data security concern by introducing Third Party Auditors (TPA) mechanism for assurance and security of data (Mei et al, 2013). TPA will verify the integrity of the data and ensure that the message exchange are authentic. The research was not able to answer many other problems and concerns such as variable standards in availability, authentication, data protection laws and many other issues that cloud users are facing while planning to adopt or use the cloud technology. Many SLAs offered by various providers do not address or provide a comprehensive solution or framework that can act as a benchmark and address the cloud adoption challenges faced by the potential and existing cloud users.

The model proposes by (Rady, 2015), is based on few applications; as model lacks on weighting mechanism of cloud services that are linked to the cloud provider. The model proposes a cloud ranking algorithm that revolves around a ranking algorithm based on functional parameters such as data security standards and privacy standards but fails to incorporate the delivered services in their framework or set standards that will defines those delivered services across the industry. The model is based around consumers' experience, involves a third party to monitor and oversee the entire process but lacks in the performance measurements and evaluation framework which can address poor or variable standards of services offered by various providers. In the next section of the chapter, will discuss Notorious Nine threats to cloud technology and how variable SLAs standards or absence of universally agreed framework are aggravating the situation further.

5.3.8 The Notorious Nine: Cloud Computing Threats

The major security challenge faced by cloud computing is security and privacy of data. The concern related to security and privacy of data is raised due to the decrease in the rate of reliability and efficiency. Security in cloud computing has become the most important topic which needs urgent attention as mentioned by (Delettre, Boudaoud and Riveill, 2016). The literature highlights cloud adoption challenges such as data security, data control, user authentication, access control issues, incident response mechanism, and due to variable set of

SLAs standards this is a serious challenges faced by the cloud industry affecting both the service providers and end users. The data security and privacy challenges are a major concern in the adoption of cloud technology. In the past many studies, researcher have tried to propose solution to improve security, privacy, efficiency and reliability of managing access and ensure authentication but still there are no uniform minimum standard of services agreed by the cloud industry. As there is absence of universally agreed SLAs and a uniform framework that can act as a benchmark for cloud service providers there is variable quality of services and standards offered by the providers. The result of this has led to many cases reported of data breaches as published by Cloud Security Alliance reports that identifies due to lack of uniform consistent model that all cloud providers have to follow and held accountable as a major adoption challenges to cloud computing technology. Different studies have identified that data related to critical applications and sensitive in nature to be hosted over the third party servers have always raised serious concerns as the data is continuously moved between the data centres network and the client setup.

The system is considered to be secure when we reduced all the threat to a minimum level that is acceptable to the organization. To provide better user authentication and access control some model are applying various solution such as Applying agent-based authentication system proposed by (Eisa et al, 2016) and multi-factor authentication process (Yichao et al, 2015), both these solutions can increase reliability of authentication process but fails to provide a comprehensive uniform model that can address serious challenges such as "The Notorious Nine: Cloud Computing Threats" as mentioned in the Table 6. Due to the absence of a uniform framework that provide minimum service level assurance to these threats mentioned in the following table there are a major barrier in the adoption and use of cloud technology.

Threat	Description
Data Breaches	Release of protected data in an untrusted environment
Data Loss	Information is lost due to improper storage, transmission or processing
Account or Service Traffic Hijacking	Attack methods such as fraud and exploitation of service

Insecure APIs	Attack on code-signing keys used by web and cloud for identification
Denial of Service	Refusing user access to their data or application
Malicious Insider	Any insider misusing their authority to harm the cloud system
Abuse of Cloud Services	Using the cloud server and service for malicious activities
Insufficient Due Diligence	Risk due to incomplete understanding of the cloud infrastructure
Shared Technology	Attack due to multi-tenant architecture, re-deployable platforms and shared resources

Table 6: The Notorious Nine: Cloud Computing Threats (CSA, 2013)

The non-functional requirements such as availability, confidentiality, integrity, scalability, response time, reliability, and monitoring and response mechanism are crucial to the cloud consumers to ensure better quality of service. The availability is the probability that the cloud infrastructure or service are up and running in the specific time of utilities of the service provided for in the SLA (Xie et al, 2015). The other non-functional requirement is scalability; the cloud provider should facilitate the specific resources for ease of scaling up and down that will maximize revenue and cloud providers are able to optimize resource effectively. There is limitation in the existing work as there is no set standards or framework that are required for non-functional requirements that states the consequences if the cloud provider is not able to offer services up to an acceptable level. Also due to the absence of the framework cloud providers are not offering an acceptable level of service and ca not be held accountable according to a framework that is agreed by all the cloud providers in the industry.

Data availability and timely access to the cloud data is another serious security challenges for the cloud providers and users. The availability of the cloud service is becoming a serious challenge as cloud services are disrupted and the best example is Amazon cloud services in year 2011 got affected resulting in no service for various website such as Reddit, Foursquare according to Amazon, 2012. Services hosted on SaaS application provider are required to ensure effective services around the clock which means infrastructural changes to add scalability, high availability and resiliency in the hardware/software failure to protect against the denial of service attacks and appropriate business continuity and disaster recovery plan as mentioned by (Martini et al, 2016). This can play a vital role by ensuring the safety of the

data and maintaining a minimal downtime for any enterprise. In the case of Amazon, Amazon Web Services (AWS), to protect against these threats are using various mitigation techniques such as synchronous cookies, connection limiting, extra internal bandwidth and world class infrastructure but these procedure and standards are different for each provider as there is no benchmark framework that all providers are following to provide better QoS regardless of their hosting location as reinforced by the authors. The confidentiality and information security is another concern of the existing and the potential cloud users. There are serious questions raised about the intentional or unintentional unauthorized disclosure of information by the insider working for a cloud service provider. The data is stored remotely and accessed while using Internet connection according to (Jin et al, 2015). The author further explains that the entire user's data can be stored at the same platform as other user's data which can lead to serious concern on data confidentiality and information security. As the data is stored outside the enterprise boundary, the SaaS vendor must adopt additional layers of security to protect and prevent any breach of data. The cloud vendors such as Amazon (EC2), administrators do not have access to customer instances and cannot log into the guest OS. Administrator with business needs are required to use individual cryptographically strong secure shell to gain access. All accessed are logged and audited routinely. In terms of audit it is not clear whether a third party is allowed to carry out the audit and what procedures are followed. The data owner will not have a physical access to the data and traditional cryptographic primitives for the purpose of data security protection cannot be directly adopted as mentioned by the author. In this scenario, there is a need of third-party auditor (TPA), which provides efficiency, transparency and fairness in performing the required audit and closes the gap between the cloud provider and users. This mechanism provides realistic security solution where cloud users achieve majority of the cloud benefits at a very minor cost, the auditing of TPA is required. Currently this is a not a required standard followed by all the cloud providers and there is a legitimate concern for the security of data and confidentiality raised by the cloud users. As cloud provides a model that is based on multi-tenancy to reduce cost and improve the efficiency to host multi-users data in the same platform (Wyld, 2009). In these circumstances the data that belongs to different users will reside at the same storage location. This environment can lead to intrusion of data from one user to another by exploiting vulnerabilities at the application level or by infecting the code at the SaaS system as mentioned by the author. There needs to be a mechanism that can define a clear boundary not at the physical level but at the application level to stop any intrusion. There is a need to have compatible solution that segregate data from the users and this solution followed by all the

providers across the industry. Currently there is no uniform standard to ensure that data segregation does not take place and different providers provide different solution to this problem. The standards vary while making storing backups as well. For example in the case of Amazon the data at rest in S3 is not encrypted by default. The cloud users has to encrypt the entire data and define a backup strategy so that it cannot be accessed by the unauthorized person and maintain confidentiality, integrity and availability. Data security, privacy, integrity and availability challenges have to be addressed so that more users can adopt cloud computing technology and feel comfortable while hosting their data on the third party servers. As for now there is no framework or mechanism that has universally agreed SLAs on the encryption standards that all cloud providers have to follow to ensure quality of service across the industry.

The next section of the chapter discusses the Service Level Agreements between the cloud provider and users, explains the negotiation process and challenges associated to the understanding and uniformity of these contracts.

5.4 Service Level Agreements

SLA has multiple stages to develop and implement the life cycle management. The five stage are Service Development, Negotiation, and Marketing, Implementation and evaluation as highlighted in the Figure 5.2 (Wu et al, 2016). The main focus is that all SLA metrics should meet the agreed requirements and if the requirements are not met then violation decision has to be made based on the rule that is violated. The main purpose of cloud computing contracts is to define the SLA and ensure that all SLA conditions are met. These SLAs are around data protection legislation, security of data, data protection, location of data, licensing and retention of data. Whereas if there is no fixed or minimum set standards that can act as a benchmark then different quality of SLAs offered by the provider will not allow the cloud users to take full advantage of this technology.

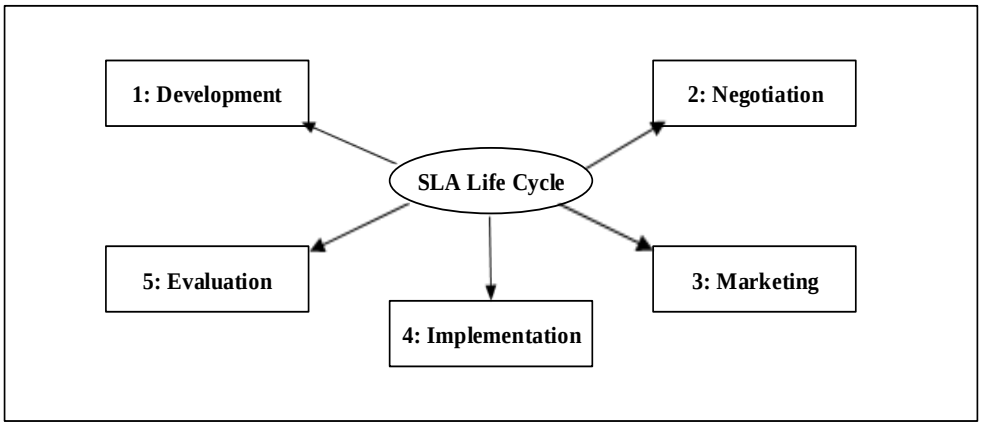


Figure 5.2 Life cycle of service level agreement (Wu, 2016)

Different models and frameworks were proposed that will enable the selection of the cloud providers. One of the major trends is Service Oriented Architecture in which the delivery of services is done by using the web service over the Internet as mentioned by (Mircea et al, 2011). The study helped to understand the management of resources and its impact on the service selection and optimization. According to the literature a new proposed cloud service selection that is based on ranked voting of the existing cloud users (Baset, 2016). The highest score will indicate the preferred cloud provider and also shows better data security and privacy. According to (Mosallanejad et al, 2016), QoS plays a key role in the service selection process especially for SaaS model. In CSMIC introduced the Service Measurement Index (SMI), which indicates various categories defined by various key entities. The model provides a Key Performance Indicators (KPI) for measuring and comparing the services. The study further elaborates that this selection technique is a complex process for ordinary users who have limited or no technical knowledge of cloud technologies and understanding of SLAs is major challenge for ordinary cloud users. The framework was not able to provide a comprehensive suite of standards that meet all the key challenges faced by the cloud users who have limited knowledge and understanding about these complex issue while using or adopting the technology. The next section of the paper discusses the SLA assurances mechanism that incorporates the requirements of cloud users.

5.4.1 SLA Assurance

In order to improve the QoS and having uniformity in terms of SLAs assurances (More, Vij, and Mukhopadhyay, 2017) introduced the SLA assured brokering framework that incorporates the requirements of cloud users. In the proposal, SLA provided by the cloud

provider to all its customers will be assured by having mechanism to measure the performance of the cloud applications. In the existing literature external cloud auditing measures the level of service provided by ranking according to the response time of the cloud providers. The author improves the model by ranking according to the quality of services which are provided by the cloud providers. (Beloglazov, Abawajy, and Buyya, 2016), introduced the KIM software framework that introduces cloud controller that reduces the service failures that resulted due to the SLA violations. These SLA violations are utilization issues, availability, and response time violation in the SaaS data centres. The existing solution was to migrate so that they can overcome this failure. In the proposed work, the focus is on the service quality and assurances to improve the performance level as stated in the SLA document. In order to improve the service quality, Sandpiper system for automated mitigation was proposed that will increase the response time of the physical machine and utilization in a virtualized data centre due to workloads. The existing literature introduces the CloudScale system (Razak, 2014), that will act proactively to overcome any upcoming SLA violation and incorporates dynamic resource allocation in the addition to the migration of the work load. The proposed model uses Markov Chain based state space approach to predict and react to the upcoming SLA violations. The worked carried out by (Salman and Baset, 2012) states that no cloud provider offer performance guarantees or allow customers to detect the SLA violation and there is a need of SLA assurance so that we can see the increase in the cloud adoption rate. In the next section of the chapter will detail the negotiation approach that is adopted in order to agree the final SLA.

5.4.2 Negotiation Approach to SLA

The SLA should be agreed after a detailed negotiation process. This process should include the end user, data centre and energy provider by considering the energy cost, energy resource and environment cost for providing services such as virtualization, integration, combination of data centre, cooling system management and UPS which cater to the high energy demands in the data centre as stated by (Klingert et al, 2016). The SLA framework should include the gradual changes of costs and client needs by introducing the automated negotiation process for SLA that includes a software mediator and providers that follows strategy based on factors such as time, market limitation, and trade off are considered. The literature reinforces that the cloud resources are priced dynamically where the computation source is variable related to free capacity. The cost optimization process can be reviewed from the service provider view such as Random, Round-Robin, Greedy permutation and algorithm such as

First-Fit used to evaluate work and compare them with implementation time. Ratio of successful cases and quality of solution (Sakr, 2014). In order to provide SLA, a trust model is presented that is based on trust management system and is called quality of service model because trust is designed based on the quality of service needs. The trust is calculated based on the four parameters such as accessibility, reliability, efficiency of returning data and data set that will be used to prepare SLA which is the combination of user quality of service needs and abilities of cloud source. The definition of SLA management depends on the negotiation process between cloud brokers, cloud providers and cloud brokers and cloud users and detailed effects of non-observing as explained by the author. The need of self-healing SLA can be useful such as HS-SLA method proposed for imposing a SLA, which is hierarchal and the mechanism includes SLA monitoring, detecting errors and reaction against that error and rapidly preventing against any errors (Sujit, 2016). This mechanism will prevent SLA errors as users will not be aware of any violations. The proposed scheme has experienced less violation as compared to other SLA strictures. In order to promote the negotiation process of SLA, safe negotiation system is proposed which is accessible for users in any time and by any device like a desktop, mobile which can reduce the overall maintenance costs as mentioned by the author. These factors will be increase the efficiency process and the success through the negotiation process to formulate SLA effectively. In the literature proposed monitoring method is suggested that automatically monitors and controls the SLAs based on the policies of the users (Sasikala and Prema, 2015). Different authors have proposed various SLA monitoring schemes which can monitor quality of service which is based on service description model and monitors SLA characteristics. The model QoSMONaaS (Nielsen and Donovan, 2016), has the ability to produce queries to design patterns or sequence of patterns which can detect violation in both pattern or find any violation that is happening currently. The model proposed is QoS aware, and contains self-management ability that possesses the features of cloud management and a quality of service factors that enables the cloud system to control and communicate system behaviour. The Table 7, shows a detailed comparison of various studies related to SLA.

Reference	Year	Goal Description	Implementation or Simulation	Implementation Environment	Workload or Application
(Vanquero LM,)	2013	1: Reduce cost of service receiver 2: Automatic negotiating	Implementation	Sigmoid & Heuristic Function	Real data
Baranwal, G. and Vidyarthi, D. P)	2016	1)Reduce service provider cost 2) Dynamic pricing	Simulation	Testbed	Artificial data
(Burkon and Lukas)	2013	Presenting Trust Model	Simulation	Cloudism	Artificial data
(Eisa, M., et al)	2016	1)Presenting Trust Model 2) SLA Management			
(Gutte, S. and Deshpande, P.)	2015	1)SLA automatic monitoring	Simulation	My SQL C#	Artificial data & empirical tests
(Guzek, M. et. al)	2015	1)Reduce service cost 2)Automatic negotiation 3)Security	Implementation	AmazoneS3	AmazoneS3 Storing Service
(Guzek, M. et. al)	2014	SLA automatic monitoring	Implementation	AmazoneS3	AmazoneS3 Storing Service
Holzinger, C. et. al)	2015	1)Present Trust Model 2)Detection before event occurrence	Implementation	Smart Meters Application	Smart Meters Application

Table 7: SLA comparison & Implementation Outcome

5.5 Implications of General Data Protection Regulation

In order to protect and provide privacy to the data the new privacy framework has been recently initiated known as GDPR (General Data Protection Regulation), which provides a new policy to deal with the challenges of privacy of the data in the information society according to EU Parliament Commission report "Unleashing the Potential of Cloud Computing in Europe" published in 2016. The regulation (EU) 2016/679, provides protection to process the personal data and provides safeguards to the movement of such data within EU members. If GDPR regulation does not explicitly states about cloud computing, about the regulation is designed with cloud computing as a central focus of attention. According to the report publish by the commission, the law will be enforced in 2018, so the cloud providers should place systems to be prepared for the new rules and avoid any major issues in terms of data security and privacy breaches as there will be serious implications for cloud providers with the implementation of GDPR law. In order to meet these new challenges and provide better security for cloud users the authentication and authorization need to be enhanced to provide a safe cloud environment. Forensic tasks are very difficult since the investigators are not able to access system hardware physically according to the EU commission report. The resource location is a major concern for the end users as most of the users do not know exactly where the resources for such services are located. This can lead to serious dispute that can happen which is not in control to the cloud providers. To save cost large amount of cloud providers are storing data across the world where data protection and privacy safeguards are not considered as rigors and comprehensive as compared to EU. This is a serious risk to the security and privacy of data as according to the data compliance and privacy laws states that locality of data has an importance for each enterprise. The European Union issued a Directive 95/46/EC that prohibits transfer of personal data to countries which do not ensure the adequate level of protection of data. There are many examples such as Dropbox users have agreed in the "Terms of Services" which grants the provider the right to disclose the personal users' information with the compliance to law enforcement request. This raises serious privacy risk to the user data which needs to be addressed or it will have serious implications of cloud industry with the implementation of General Data Protection Regulation. The existing SLAs offered by the cloud providers are not adaptable to the changes that will effect according to the new regulation. There is a need for a uniform SLA model or a framework that can cater to the needs of GDPR and provide security and privacy to the cloud user's data and provide protection to cloud providers against any litigation.

5.5.1 General Data Protection Regulation: New Provisions and impact on Cloud Service Providers: An Uniform Approach to Data Protection Laws in EU

The GDPR will provide a uniform approach to the data protection law in the all the member states in the EU by having a single set of rules on data protection across the union. The law will replace the existing inconsistent national data protection law that have created confusion and ambiguity. The law will be immediately and at the same time will be implemented on all member states and the previous Data Protection Directive will not be valid anymore. This law will provide a uniform approach to the data protection and cannot be changed or weaken by various member states at the national level. The massive legislative change is being welcomed by cloud service providers as it brings a uniform single data privacy law across the all the member states by reducing the operational cost and ensuring ease in compliance activities. The will allow the providers to compete effectively and assist businesses to grow their operations. The cloud providers in EU can have a competitive advantage by incorporating these directions and improve the Quality of Service (QoS) and standards. Whereas the providers across the world have to incorporate all these changes into their processes and procedures.

5.5.2 Processer fully Accountable

In the existing Data Protection Directive, data controller is solely responsible and accountable to maintain the security and privacy of data whereas data processor carries no legal burden. According to the Directive rule data processors are processing data for data controllers and are not subject to data protection and security rules. There are serious implications of GDPR on data processor by including the processor in the ambit of rules now. With the new law the processor are directly accountable for data processing so the cloud service provider CSP processes and operations will be affected. CSP cannot avoid the accountability anymore and in order to incorporate the law have to further develop and implement number of internal procedures and practices to safeguard data. The problem that should not be overlooked is the burden the law will create on the small size CSP processors.

5.5.3 Applicable to Non-EU Companies

With the implementation of GDPR it will extend the reach of territorial scope of the EU data protection law to all providers that processes personal data for the EU resident. The existing

DPD does not cover the situation where the controller is outside the EU and process personal data for EU customers. The current DPD is quite inadequate, unclear and confusing dealing with the new technological advancements. The GDPR removes any ambiguity that any organization that is based outside the EU that are processing personal data have to abide by the GDPR law and also will be held accountable. The cloud providers operating from outside the EU need to improve their processes and procedures to match the same Quality of Service (QoS) and standards offered by their competitors that resides in the EU.

5.5.4 Appointment of Data Protection Officer

The GDPR law stipulates a mandatory requirements for all companies and CSP to appoint Data Protection officers (DPO) to oversee the maintenance and security of the data. The law requires an appointment of DPO by the controller and the data processor where more than 5000 data subjects are being processed for more than 12 months in a period. The core responsibility of DPO is to be independent and have professional qualities and expert knowledge to maintain the data protection law and ability to fulfill the responsibilities mentioned in the Article 37. The GDPR will enforce the processing of data by the controller or it can be processor that is based in any member states of the EU. The law is applicable to the processing of personal data of data subjects that are in EU by controller or processor that does not exist in the EU. This enforces an appointment of DPO to the data processor that does not exist in the EU. The implication of appointing the DPO is another financial burden on the CSP which will overall increase the customer's service fees.

5.5.5 Relevant implications with Subcontracting

There are serious implications for CSP processor due to Article 26 that stipulates clearly processor without the advance written consent of the controller cannot subcontract to the other processor. So it is clear that any subcontracting can only take place if advance consent is taken. The law allows an open consent to subcontracting to processing of data if agreed upfront. The law stipulates that CSP processor have to inform the data controller in advance of any changes which will provide the opportunity to the data controller to stop any changes that can compromise the security or privacy of the data. The implications due to Article 26

will force the CSP to change their existing procedures and can create an operational burden for some providers.

5.5.6 Data Breach Notification

According to the GDPR it is essential to report any data breach to the concern stakeholders without any delay. The data controller has to inform the responsible supervisory authority in the EU. The law stipulates that any data breach should be informed to the data subject with close cooperation with the supervisory authority. As soon as the organization is aware of the data breach they have 72 hours windows to notify the authority. The Article 33(3) stipulates four requirements when reporting a data breach should be highlighted such as the notification within the reasonable time (the mentioned 72 Hours), the nature of personal data breach containing the categories of data and numbers of data subject records breached, provide the name and contact details of the data protection officer and explanation to the cause of the consequences of the data breach. This provision of the law will impact the existing processes and will require more resources in-terms of manpower to accommodate the new provision of the law.

5.5.7 Right to Data Portability

Data subject has full authority and right to request the data to be moved under the Article 20 of the law. The article states that the personal data that is stored with the controller can be moved to another controller upon the request of the data subject.

5.5.8 ONE-STOP Initiative

As per the GDPR all EU residents and different data processor and controllers will deal with only one DPA (Data Protection Agency) across the EU. Different organizations in each member states will have a DPA in the country where they are established. This will increase the uniformity and eliminate any ambiguity and ensure that all decisions are locally made. This will allow CSPs to work closely with the DPA to improve the overall efficiency and enhance the protection of the data.

5.5.9 Serious Penalties for Negligence Breach

There are serious implications in terms of financial penalties if there is a 'negligent breach' that leads to data and privacy loss. The law proposes a fine up to 5% of annual revenues and maximum fine up to 100 million euros. There is new potential offence that can have serious consequences to the data breach is known 'Unjust Enrichment'. This is happened when the company save money and does not apply enough security measures to protect data which results in data security breaches. The EU commission is planning to incorporate this into law which will have serious implication of CSPs.

5.5.10 Right to be forgotten

The law clearly stipulates that if EU resident no longer want their data to be processed or store they can request the complete removal of data. The burden is on the organization to completely remove the data and do not keep any information about the specific user.

5.5.11 Comparison of DPD Vs GDPR

The GDPR provide a uniform approach to the data protection law in the all the member states in the EU by having a single set of rules on data protection across the union. The law will replace the existing inconsistent national data protection law that have created confusion and ambiguity and proposes new provisions as seen from the Table 8, that will improve data security and privacy but at the same time will have serious implications for CSPs and their procedures and processes with the implementation of GDPR.

Current Data Protection Directive 95/46/EC	Changes created by GDPR
European reach only	Global reach
Local law divergence across 28 EU states	Regulation: uniform across EU
Multiple Data Protection Authority ("DPA") Exposure	"One stop shop"
Limited Accountability	Accountability Key
Controllers Only	Controllers and Processors
Small fines, differ between countries	Huge fines
No obligation to report breaches	Obliged to report breaches without delay
No obligation to have DPO (Data Protection Officer)	DPO required for larger organization

Table 8: Changes in existing EU Data Protection Law (EU Data Protection Policy Regulation, 2016).

5.6 Green Energy SLA

With the large usage of cloud computing services the question is that how green are these services. The demand for green services have grown due to social awareness, the desire to provide green services and establish Green SLAs is crucial for cloud infrastructure providers according to (Srinivasan and Getov, 2014). The challenge for cloud provider is to manage Green SLAs with their customers while satisfying their business objectives such as maximizing profits by lowering expenditure for green energy. In the existing literature the scheme for green energy management in the presence of explicit and implicit integration of renewable energy in the data centre. The literature proposes the concept of virtualization of green energy to address the uncertainty of green energy availability. The literature extends the Cloud Service Level Agreement (CSLA) to support Green SLA by introducing two new threshold parameters to offer SLA that meets the environment and green SLA requirements. The literature introduces green SLA algorithm that introduces a concept of virtualization of green energy to provide per interval specific Green SLA. In contrast, Power driven approach implies, shifting or scheduling the deferrable workloads to the time period when the price of electricity is lower or migrating workloads to the different region (data centres) where the electricity price is cheaper than the origin with respecting the deadline. On the contrary, Green power driven SLA can be realized as: end users or SaaS providers shift their

workloads in a renewable/green energy powered data centre having an agreement with IaaS provider that some portion of their workload should run in a greener environment. Existing literature does not provide a clear idea about the advantages and disadvantages of different integration option of renewable energy sources in data centres. Although according to (Radha et al, 2015) have explored the opportunity of integrating renewable sources in data centre, but lacks the explanation of how SLA should be established between IaaS and SaaS providers based on the green energy availability.

To address this problem, the literature proposes a green power driven SLA framework established between SaaS and IaaS provider stating that, IaaS provider provides infrastructure with proportional e.g., 30 percent green energy availability. For instance, IaaS provider will have a formal contract with SaaS provider to provide green infrastructure based on a business model. In position to these existing research, the work can be seen as complementary to their research since reducing energy consumption in infrastructure level and associating green sources can reduce carbon footprint in data centre from the global point of view. The literature argues that Green SLA should be established by taking into account the presence of green energy rather just reducing the energy consumption in the infrastructure level. The existing SLAs offered by the cloud providers are not adaptable to the changes that will effect due to Green SLAs requirements by the cloud users. There is a need for a uniform SLA model or a framework that can cater to the needs of Green SLAs.

5.7 A discussion on the Problems and Challenges in the Adoption of Cloud Technology

In the following section the researcher will analyze the literature review in the above section and summarize all the adoption challenges to the cloud computing due to the absence of a framework or a universally agreed mechanism that can act as a minimum benchmark to the level of service provided by the cloud providers. According to the literature, cloud computing is gaining popularity organizations and users are having problems to adopt the service due to lack of minimum service level framework which can act as a benchmark in the selection of the cloud provider and provide quality of services according to the user's expectations. The situation becomes more critical due to distributed nature of the service provider which can be offering service from any part of the world. Due to lack of minimum service level

framework that will act as a benchmark to provide a uniform service across the industry there are serious concerns raised recently in-terms of security and data privacy breaches, authentication and authorization issues, lack of third party audit and identity management problems, integrity, confidentiality and variable data availability standards, no uniform incident response and monitoring standards, interoperability and lack of portability standards, identity management issues, lack of infrastructure protection services standards and weak governance and compliance standards are major cause of concerns for cloud users. Due to confusion and absence of universal agreed SLAs for a service model, different quality of services is being provided across the cloud industry. Currently there is no uniform performance model agreed by all stakeholders; which can provide performance criteria to measure, evaluate, and benchmark the level of services offered by various cloud providers in the industry.

To address the above adoption challenges to the cloud computing technology there is a need to design a conceptual model that can address the key concerns of the existing and new cloud users while adopting or using the cloud computing technology. This conceptual model will provide guidelines to a minimum standards that will act as a benchmark to measure, evaluate and assess the QoS of cloud providers. The proposed model will have a reaching impact and can be widely adapted across various organizations that are struggling due to lack of uniformity in terms of quality of services offered by various cloud providers. The literature clearly identifies that potential cloud users are concerned due to the security, privacy, integrity, confidentiality, and availability of data, serious interoperability issues, lack of third party audit mechanism, problem resolution, and weak guidelines on data protection regulations while using the cloud technology. According to the analysis of the literature it was clear that these problems are the adoption challenges in the selection of a cloud provider and affecting the adoption rate to use the technology. It was evident from the literature review there should be a framework detailing the performance indicators or parameters to measure and assess the performance of the various cloud providers which will ease the process of selection of cloud providers, compare and evaluate the performance, act as a performance benchmark, make the cloud providers accountable and improve the overall (QoS) standards in the cloud industry.

5.8 The Proposed Model: MSL Framework (Minimum Service Level Framework)

Cloud Computing ensures parallel computing and emerged as an efficient technology to meet the challenges of rapid growth of data that we experienced in the Internet age. The technology has enormous benefits but there are serious concerns and challenges related to the lack of uniform standards or nonexistence of minimum benchmark for level of services across the industry to provide an effective, uniform and reliable service to the cloud users. As the cloud computing is gaining popularity, organizations and users are having problems to adopt the service or to compare the QoS offered from different cloud providers. This is due to lack of minimum service level framework which can act as a benchmark in the selection and comparison of the cloud provider and provide QoS according to the users expectations. As there is no minimum service level framework that can act as a benchmark to provide uniform services across the industry, there are serious concerns raised recently in terms of security and data privacy breaches, authentication, authorization and accountability variable standards. Concerns such as lack of third party audit and poor identity management, variable level of standards, integrity and different availability standards, confidentiality concerns, integration problems and no uniform incident response and monitoring standards have been reported by cloud users. For this research a specific case study of Higher Education institutions is investigated to find the problems and challenges in the adoption of cloud computing technology. If we examine the literature and apply the adoption challenges of cloud computing technology to the specific case study the following are main concerns and challenges to be addressed as mention in Figure 5.3. In the specific case study there are four main stakeholders that will be affected with the implementation of the cloud computing technology which are Students, Staff, Senior Management and the Technical support team as represented in the Figure 5.3

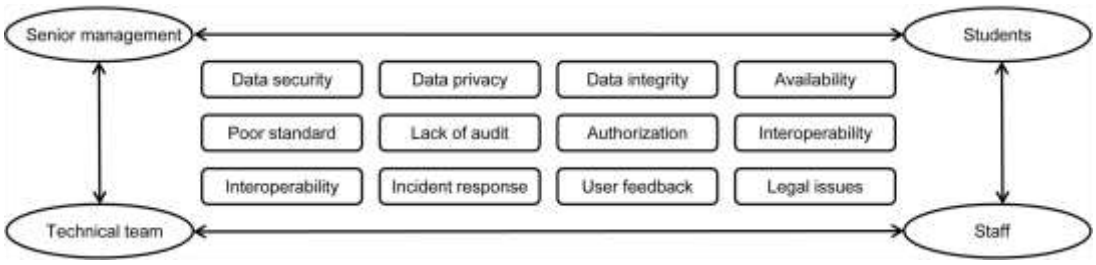


Figure 5.3 Adoption Challenges to Cloud Computing Technology

As the number of (HE) institutions are increasing to use cloud computing technology it is crucial to have universal agreed minimum service level framework that all providers have to follow and will be held accountable. The framework or model that clearly defines a minimum set of performance criteria to meet the adoption challenges and issues which are faced by the users in the HE institution. The proposed framework has to address the legal issues, related to data protection that is stored over the cloud, as it is a major source of contention for cloud users and it is affecting the adoption rate to the technology. The proposed framework Minimum Service Level (MSL) framework as shown from the Figure 5.4 to provide a uniform minimum service level model that acts as benchmark for the cloud industry to ensure consistent QoS to the cloud users. The main contribution of the research is to investigate and implement a MSL (Minimum Service Level) Framework for an higher education institution case study, to offer universal agreed standards of services that will act as a benchmark for all the providers across the cloud industry regardless of their hosting location. The proposed framework addresses all the adoption challenges faced by the cloud user and act as minimum benchmark for quality of service standards. This minimum framework will measure, evaluate and make cloud providers accountable for the quality of service offered. The proposed framework will consist of set guidelines that will ease the process of cloud provider selection and cloud users can compare the level of service offered against the framework. The proposed framework will be implemented in the HE institution but can be implemented in other sectors as well.

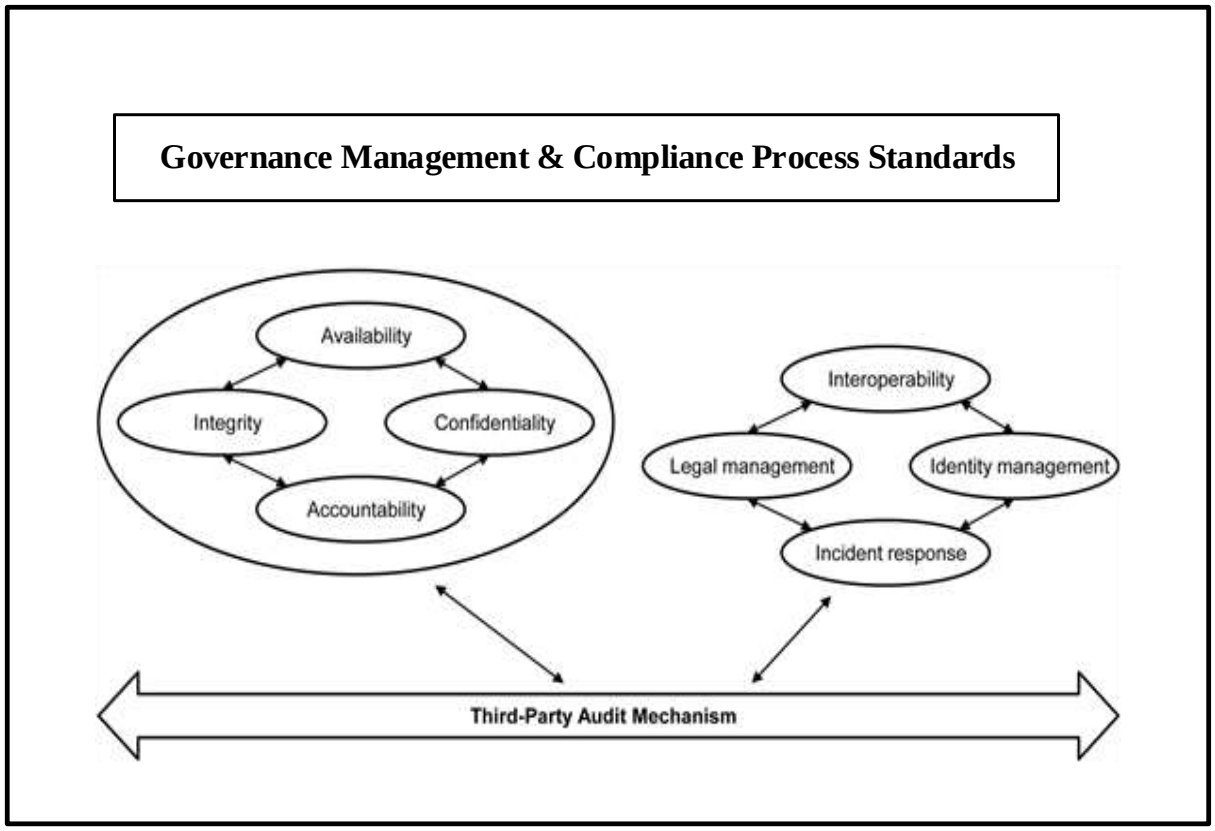


Figure 5.4 Proposed Minimum Service Level (MSL) Framework

The proposed model plays a vital contribution in the field of cloud computing technology as we are experiencing the increase number of HE institutions using the service which is raising many serious questions and the one which needs urgent attention is: what type of minimum QoS level should students, staff, senior management and employees of the educational organizations should expect from the cloud industry. The MSL framework addresses concerns of cloud users in a HE institution about the providers hosting services from different parts of the world where security, privacy and other standards are not very rigorous as compared to the standards we experience in European Union. The MSL framework will provide a minimum service level model or a framework that will acts as uniform universal standards for HE institution regardless of their size; and address serious concerns raised by cloud users in terms of data security, integrity, availability, privacy breaches, authentication and authorization and lack of accountability mechanism. The proposed framework will address issues such as lack of third party audit, identity management concerns, confidentiality and no uniform incident response and monitoring standards. The framework will ensure that

it cater the needs of GDPR and address any regulatory issues which are a cause of concern for all the respondents as well as the cloud industry.

The proposed model will assist the HE institution to select the cloud provider that provides best QoS as expected from the cloud users. The proposed model provides uniformity across the cloud industry setting a guideline for all the cloud providers to follow the minimum standards regardless of their location around the world. The MSL framework is crucial to have universal agreed minimum service level agreement that all providers have to follow and implement which becomes minimum standards across the industry. The framework will remove hurdles and challenges that are faced by the HE institution to find out which provider they should trust their data with; ease the selection of the cloud provider and improve the overall QoS offered across the cloud industry. The MSL framework will play a vital role by allowing the users to compare, assess, and decide which cloud providers is better in terms of service offered. The MSL framework will act as benchmark that will define the level of services that each cloud provider will be evaluated and rated at. The proposed framework will address all the concerns raised by the cloud users and improve the overall adoption rate of the technology. In the next section of the chapter the researcher will explain the guidelines of the proposed framework and explain all the key entities addressing the adoption challenges of cloud computing.

5.8.1 Cloud Computing Implementation Evaluation Criteria

In order to implement a MSL Framework cloud computing solution there is a need for an evaluation criteria in the MSL Framework. The research contributes by compiling an evaluation criteria as seen from Appendix V. The purpose of the "Cloud Computing Implementation Evaluation Criteria" is as follows:-

- To provide a set of standards for cloud service providers and cloud users as to what security features is a requirements in the implementation of cloud computing in the organization.
- This document will ensure that cloud service providers will integrate security to satisfy the cloud user requirements, maintain CIAA (Confidentiality, Integrity, Availability, Authentication) standards and particular emphasis on maintaining standards across the cloud computing industry.

- To provide potential cloud users with a metric with which to evaluate the degree of trust that can be placed on the cloud service provider and ease of the selection of the cloud service provider.
- To provide a basis for specifying security requirements in acquisition specification.

5.8.1.1 Three Phases of Implementation Criteria

The Cloud Implementation Evaluation Criteria has three phases as seen from Appendix V. Each phase has different level of criteria and credentials to ensure different level of security in the implementation of cloud computing.

1: Minimal Standards: As the name suggest provides minimal protection and meets minimum requirements standards in terms of CIAA standards and other key requirements.

2: Medium Standards: The second phase contains mediocre protection and meets some requirements in terms of CIAA standards and other key requirements..

3: Enhanced Standards: The last phase contains enhanced protection and meets all the requirements in terms of CIAA standards and other key requirements.

5.8.2 Availability Standards

The proposed MSL (Minimum Service Level) Framework will provide set standards for the availability of the service. The proposed model recommends the level of uptime to be 99.999% and percentage of successful request processed to be also 99.95%. The proposed MSL framework to improve the availability standards recommends that all request should be processed in a timely manner without any delay as shown from the Figure 5.5 Availability Standards in the MSL Framework.

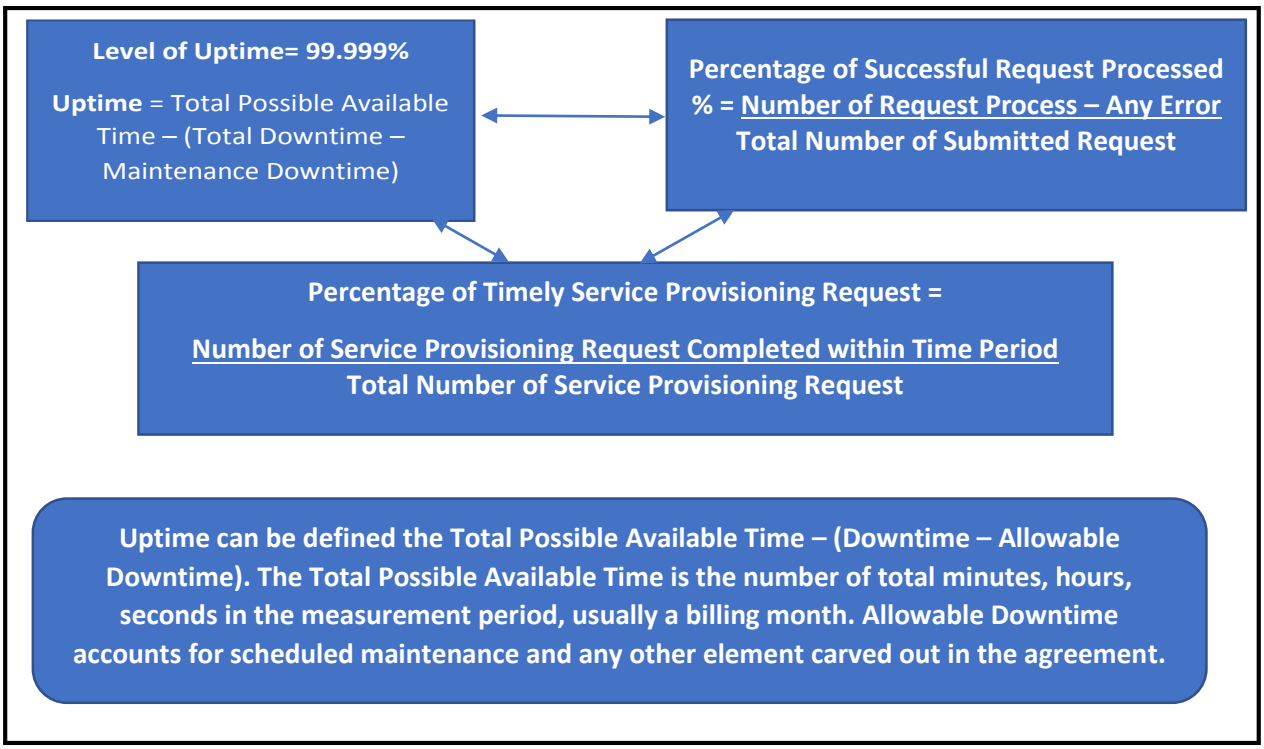


Figure 5.5 Availability Standards for MSL

5.8.2 Data Security and Encryption Standards

The proposed MSL (Minimum Service Level) framework recommends to implement ENCRYPT II or FIPS security as a minimum standards. To ensure data security and enhanced encryption standards which is mandatory to implement Cryptographic Hardware Module and produce, store and manage key themselves rather than relay on the third party provider. The proposed MSL framework should use content aware encryption to protect against Data Leak Prevention and understand data types. The proposed framework as shown in Figure 5.6 Data Security and Encryption Standards to use Format Preserving Encryption to preserve data types and format using block cipher encryption and defines a detailed method to protect key from access as shown from the Figure 5.6.

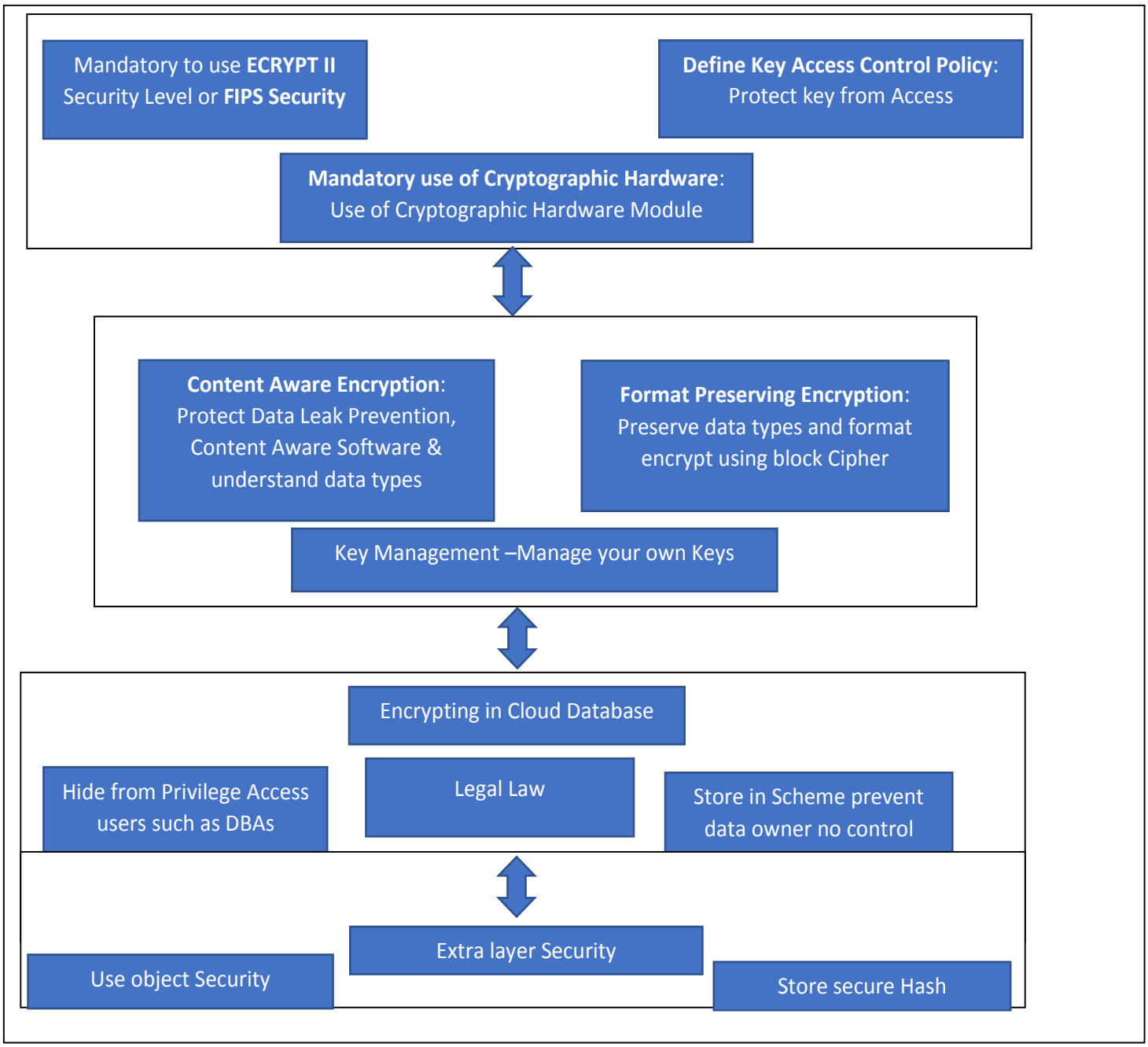


Figure 5.6 Data Security and Encryption Standards

The proposed MSL framework recommends to encrypt data that is stored in the cloud and prevent any access from the DBA – Database Administrator as well to ensure data security, confidentiality, integrity and privacy. The data is stored in scheme that prevents data owner no control and extra layer of security is in place by storing the hash value and implementing the object security in the proposed framework. The encryption of data will have no value if

both providers as well as users of cloud services do not vigorously enforce the processes around key management. On the provider side a lack of Segregation of Duties (SOD), around access around access to key servers and servers having encrypted data should be a cause for concern, as well as DBA's having access to individual keys for databases, or the architecture of the database service reliant on a single key. Controls around protecting the keys themselves, by using KEK (Key Encrypting Keys) and generation of encryption keys in-memory, and only storing the encrypted key of key servers are all valid architectural solutions that should be considered in the proposed model.

5.8.3 Data Encryption in Cloud: Factors Integrated in the Proposed Framework

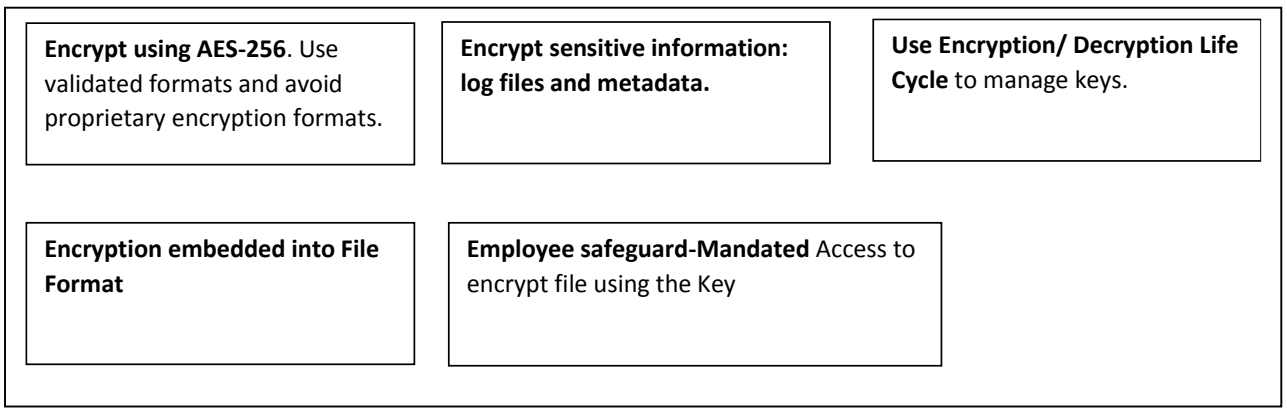


Figure 5.7 Data Encryption in Proposed MSL Framework

Recommendation – Key Management

The following requirements are entrenched in the proposed framework which are as follows:-

- In the proposed framework, implement best practice of key management practices when using any form of encryption/decryption product;
- Use best practice key management practices and obtain technology and products for encryption, decryption, signing, and verifying from credible sources;
- In the proposed framework is highly recommended that organizations maintain, store and manage their own keys;
- Key scoping is recommended so it can maintain at the individual or group level;
- Group access can be managed with off-the-shelf technology such as DRM systems and other software running on the desktop/laptop that encrypts disks, folders, and email messages in the proposed framework.

Recommendations – Encryption within Databases

The following recommendations must be met:

- Use standard algorithms, minimum AES (Advanced Encryption Standards – 256) to be used in the proposed framework. In the proposed framework it is recommended not to use or invent proprietary scrambling techniques or encryption algorithm as they are unproven and easily broken;
- Avoid old insecure encryption standards such as Data Encryption Standard (DES);
- Use object security in the proposed MSL framework. Implement basic object security (SQL grant and revoke statements) to prevent access to even the encrypted data;
- In the proposed framework it is recommended do not encrypt primary keys or indexed columns. If you encrypt a primary key, you will have to encrypt all referencing foreign keys. If you encrypt an indexed column, you may end up with slow queries when trying to use the encrypted value.

Best Practices in Proposed MSL Framework

The following proposals are listed:

- The proposed MSL framework recommends to maintain best practices and pass audits the organization should manage their keys in the custody of their own enterprise or that of a credible service from a cryptographic service provider;
- Keys used in existing encryption technology such as DRM and disk encryption products should be managed by central, internal to the enterprise, key storage technology. Hardware Security Modules (HSM) should be used to store keys as well as process cryptographic operations such as encryption/decryption, signing and verifying;
- The proposed MSL framework recommends that enterprise users should go through a registration process to enable cryptographic operations and other processes in the enterprise, such as Content Aware or Format Preserving systems can access encryption/decryption keys as needed;
- Deploy technology integrated into corporate systems based on the identity of all components in the processing chain to make entitlement decisions;
- Manage keys used by the cryptographic processes using binding cryptographic operations.

5.8.4 Authentication Process Standards

In the proposed MSL framework, ISO/ IEC 29115, Entity Authentication Assurance Framework is recommended to be integrated to address the authentication adoption challenges faced by the cloud users. The authentication standards are very crucial, provides consistency and form the basis for trust in the proposed model. Authentication is a large barrier to the deployment of the cloud computing technology as follows:

- There is no universal citizen credential;
- Application specific credential are difficult and expensive;
- Identity Proofing is a problem;
- Forgotten passwords from infrequent usage;
- Help desks and other maintenance overhead;
- Multiple collection of personally identifiable information (PII).

The standards in the proposed MSL framework will promote identity federation and helps organization to make informed decisions. It promotes efficiency, reduce costs and enable credential reuse in different scenarios. These standards will ensure cross border and cross-organization services. The proposed MSL framework is recommended to use the authentication scheme based on cross certification for digital certificate-based authentication as shown in the following Figure 5.8. The proposed framework introduces features such as mean time to revoke user access and provides user access storage protection. As shown from the following figure to ensure interoperability, third party authentication is recommended that will maintain standards, identity management solution and authentication standards should be integrated in the proposed MSL Framework.

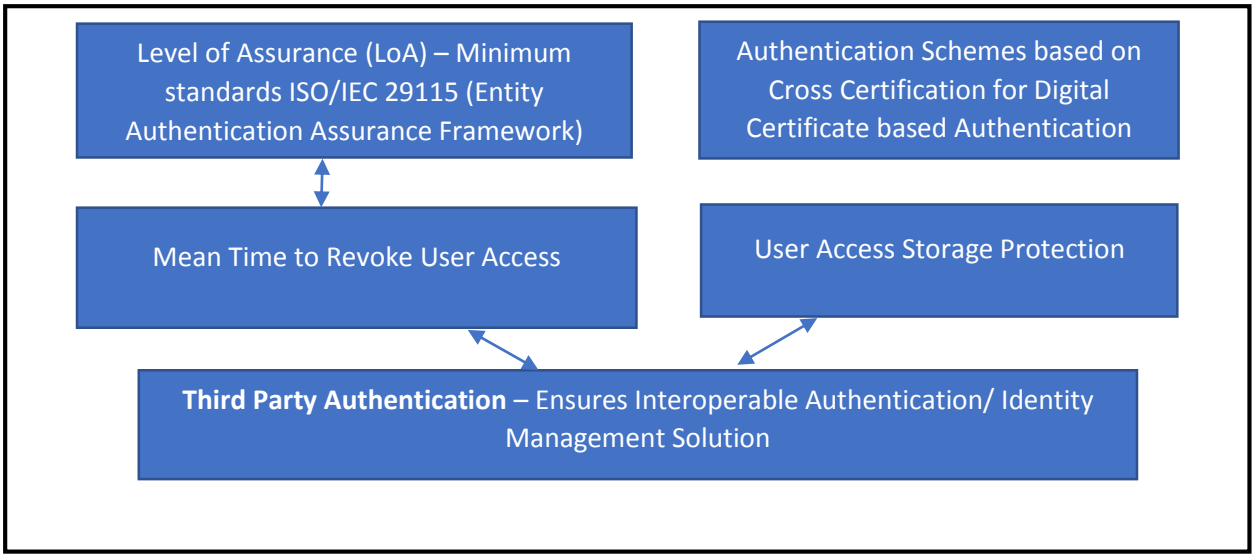


Figure 5.8 Authentication Standards in Proposed MSL Framework

In the proposed MSL framework the use of ISO/ IEC 29115 for managing entity authentication assurance as shown from the following figure will provide:

- Four Levels of entity authentication assurance;
- The framework details specifies criteria and guideline for each of the four levels of entity authentication assurance (Figure 5.9 and Figure 5.10);
- Provide guidance concerning controls that should be used to mitigate authentication threats;
- Framework maps the four level of assurance to other authentication assurance schemes;
- Provide guidance for Entity Authentication Assurance Standards in the proposed MSL framework as shown in the Figure 5.9.

Level 3- Entity Authentication Assurance Standards

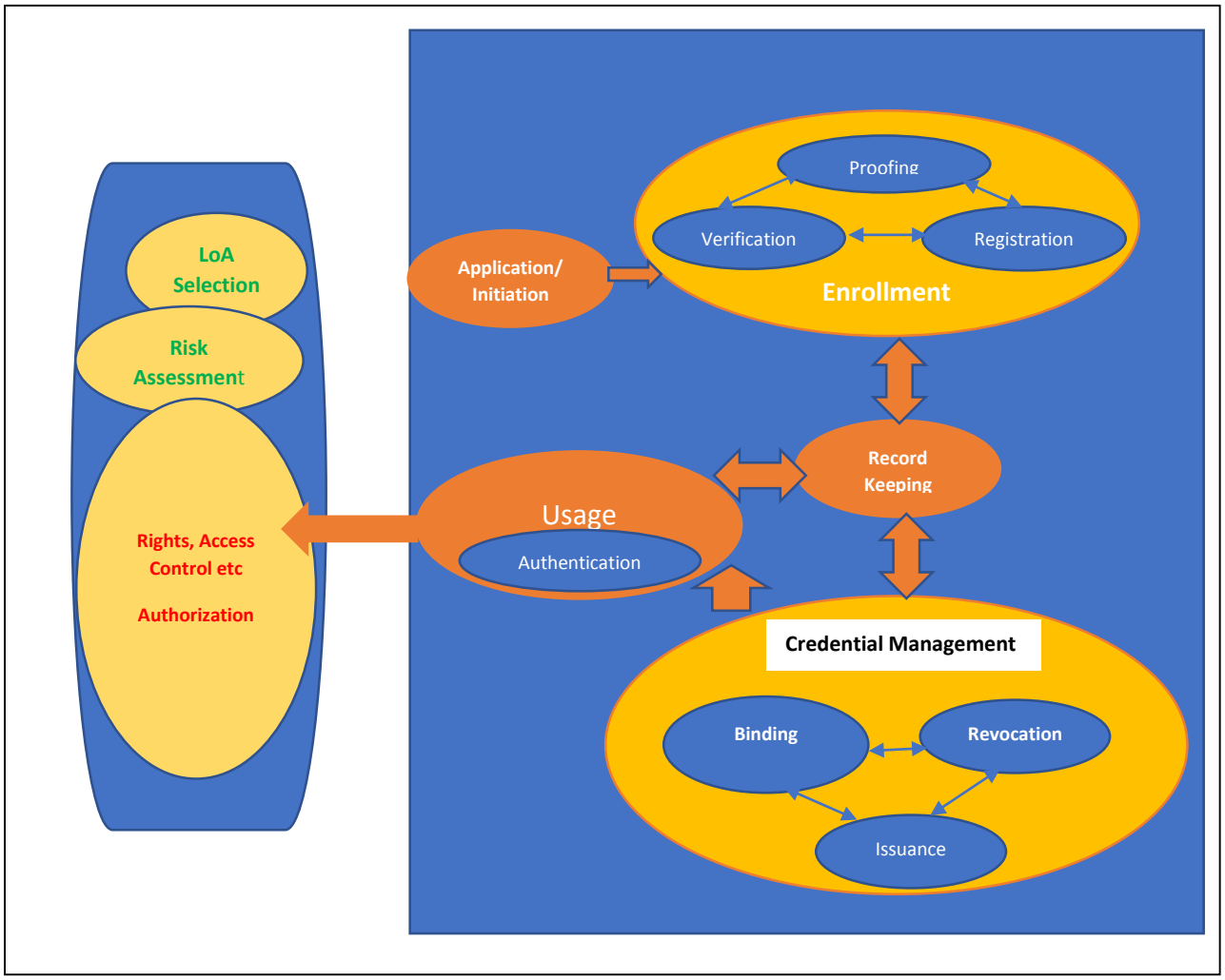


Figure 5.9 Entity Authentication Assurance Standards in Proposed MSL Framework

4 Level of Assurance

Level	Description
1—Low	Little or no confidence in the asserted identity
2-- Medium	Some confidence in the asserted identity
3—High	High confidence in the asserted identity
4—Very High	Very high confidence in the asserted identity

Figure 5.10 Four Levels of Assurance

5.8.5 Authentication Standards Requirements in MSL Framework

In the proposed MSL framework the process of authentication is to validate or confirm that access credential provided by a user using the user ID or password are valid. A user can be person or an application should be authenticated to access any resource. Many enterprise applications require that users authenticate before allowing access. The creation of a user and managing the life cycle is addressed by identity provisioning, the authentication challenge is to manage credential including the passwords, digital certificates and dynamic credentials. The authenticating users have the following challenges:

- Protecting the password and communicating it securely;
- Impersonation: When the same password is used for various cloud services, an insider or an attacker who can gain access to the password store might capture passwords and impersonate users at other sites;
- Protecting the password from brute force dictionary based password attacks;
- Phishing: Cloud user can be vulnerable to the phishing attack to extract usernames and passwords.

In order to provide authentication the proposed MSL Framework should have the follow the model as shown in the Figure 5.11. The key highlights are as follows: SAML Token should be used as Security Assertions Mark-up Language tokens are XML representations of claims. SAML tokens carry statements that are sets of claims made by one entity about another entity;

- Multifactor authentication should be integrated in the proposed framework which relies on two or more factors where a factor is "something you have" such as a smartcard, "something you know" such as a password or pin, and "something you are" such as a physical fingerprint;
- OTP (One Time Password) used for authentication which is valid for small period of time;
- Risk based authorization is used in which the type of authorization uses roles instead of the user credentials to determine access rights and privileges;
- A flexible and feature-rich extension to SOAP to apply security to web services. The protocol specifies how integrity and confidentiality can be enforced on messages and allows the communication of various token formats such as SAML, Kerberos and X.509;
- Password Management Policy and network authentication mechanism will be integrated in the proposed framework;

- One implementation of SSO is Kerberos to provide easy access and prevent multiple password requirements for various application as shown from the following Figure 5.11.

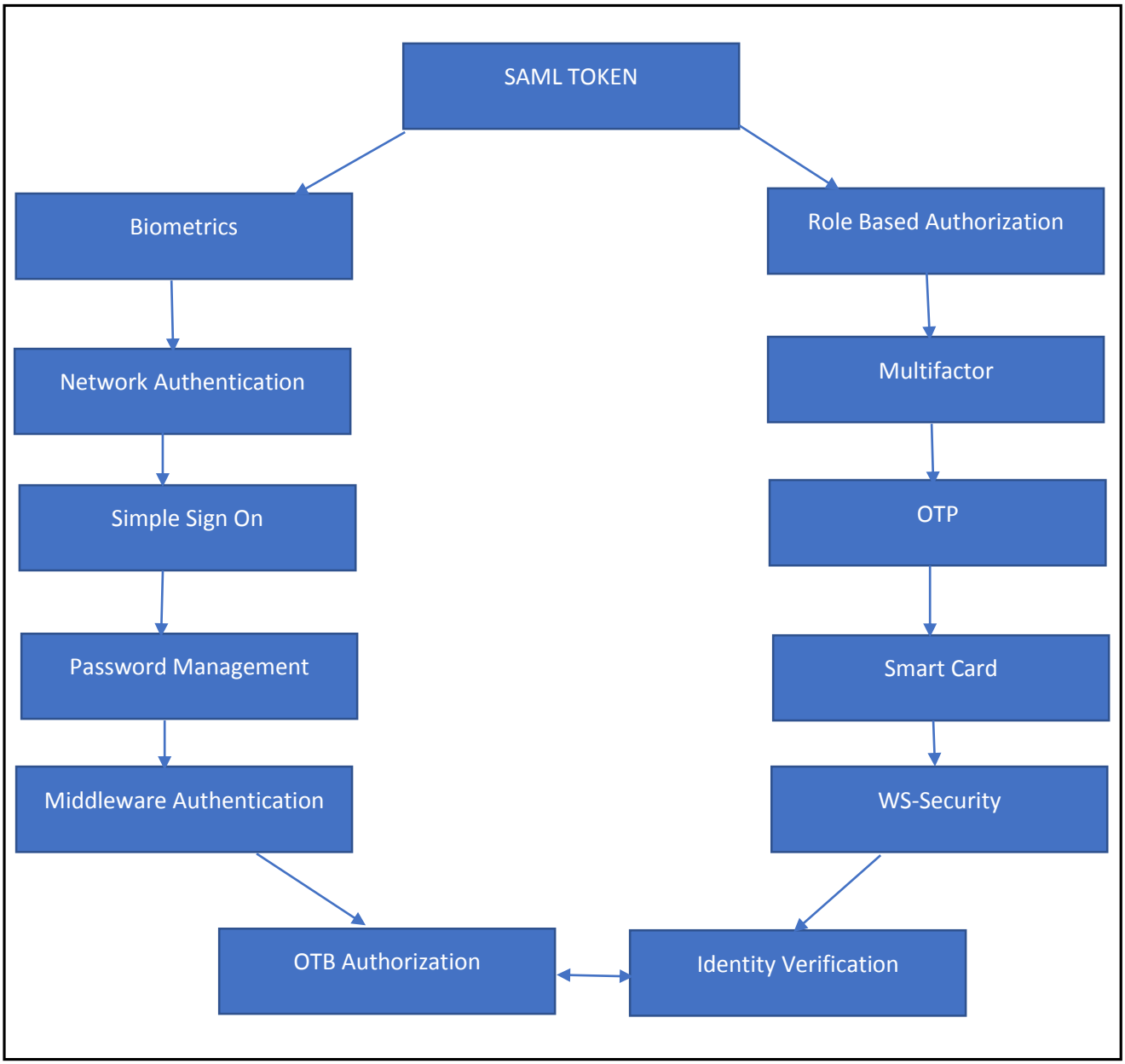


Figure 5.11 Authentication Standards in the MSL Framework

SAML TOKEN	Security Assertions Markup Language tokens are XML representations of claims. SAML tokens carry statements that are sets of claims made by one entity about another entity.
Role Based Authorization	A type of authorization that uses roles instead of the user credentials to determine access rights and privileges.
Multifactor	"A form of authentication that relies on two or more <factors> where a factor is <something you have> such as a smartcard, <something you know> such as a password or pin, and <something you are> such as a physical fingerprint or a behavioural keyboard cadence."
OTP	One Time Password is a password that is valid for a short period of time (e.g. only one login session or transaction) and is aimed at avoiding a number of shortcomings that are associated with traditional static passwords. One of the most popular approaches for generating OTPs is time-synchronization between the authentication server and the client. OTP implementations are often used in two factor authentication solutions where the user enters a pin which is used as a variable in an algorithm that generates evidence of identity which is sent to an enforcement agent that determines if the identity is valid.
Smart Card	A smart card (aka microprocessor card, chip card or integrated circuit card) has traditionally taken the form of a pocket-sized card with embedded integrated circuits. Smart cards are often used in two factor authentication solutions where the user enters a pin which is used by an operating system on the smart card to release evidence of identity such as a digital certificate or to allow a private key to sign an identity token which is sent to an enforcement agent that determines if the identity is valid.

WS-Security	A flexible and feature-rich extension to SOAP to apply security to Web services. The protocol specifies how integrity and confidentiality can be enforced on messages and allows the communication of various token formats such as SAML, Kerberos and X.509.
Identity Verification	The identification of living individuals by using their physiological and behavioural characteristics or derived documents issued by an authority.
OTB Authorization	A method for applications to implement user login functionality through identity provider's service without custom authentication code.
Middleware Authentication	Authentication of applications/services/components that users never, ever see directly.
Password Management	The ability to specify multiple password policies, define constraints on password composition, maintain password history, restrict passwords, configure password validity period, create password rules, etc.
Single Sign On	A property of access control where a user logs in once and gains access to many other systems without being prompted to log in again at each of them. One implementation of SSO is Kerberos.
Network Authentication	Authentication services that provide methods/protocols for users (or devices) to logon to a network and other benefits (e.g. SSO).
Biometrics	Biometrics consists of methods for uniquely recognizing humans based upon one or more intrinsic physical or behaviour trait. Biometrics are used as a form of identity is used for authentication and access control.

Table 9 Authentication Mechanism in the Proposed MSL Framework

5.8.6 Authorization Services Standards

In the proposed MSL Framework authorization service standards should be deployed to address the adoption challenges. Different types of system entities consume those services; therefore, application service provider should manage a proper mechanism for access control decisions. This means that various users, after being successfully authenticated, should request and access those resources and services for which they are authorized in a particular enterprise security domain. As the number of the services and service consumers grow, management of access control mechanism becomes more complex and expensive: each service provider needs to implement independent access control mechanism by means of self-governing security policies and policy enforcement points. Having a single security policy management point makes the entire authorization system more flexible and secure, meaning that it can be administered, configured and protected separately from application services. In this way, it is easy to configure and apply common policies for every application service in a single security domain.

In the proposed MSL Framework, role-based authorization system is proposed for a cloud environment which is a component of the central security system. XACML is the main standard adopted for this authorization system. To address the authorization challenges the system provides authorization services for cloud based application services. As shown from the following Figure 5.12 (Authorization Standards), role based access control mechanism and provides authorization services to application service providers within a security domain. Policy Administration Point (PAP) component is in charge of providing policy administration services to security administrators. It is the main repository for policies and authorization service provider makes authorization decisions based on security policies created and stored in that repository by security administrators. To address the authorization challenges the designed security system PAP component is deployed in the PDP server. End users, that may access resources at an application service site, must be assigned different access roles by security administrator. PAP provides role defining and assigning services to authorized security administrators. In order to assign a role to an end user, the latter should have a valid registration entry in IDMS. PAP and IDMS are coordinated together and they share a repository for storing and retrieving end user attributes, such as roles. At the same time, security administrator defines role based policy: it represents authorization result based on a

combination of resource, action and role. Thus, the complete decision service is centralized in a single security system. XACML policy language is used for creating policy files. When a user sends a request to access some resource or service, PEP server intercepts user's request and creates an XACML authorization request. Then the request is sent to the PDP service provider. PDP service provider makes an XACML authorization evaluation against already created policies and returns an authorization decision result back to the PEP. PEP server is responsible to enforce the authorization decision through granting or denying the access for a particular resource or service. As in the case of SSO service, authorization service metadata, which contains the WSDL or the WSDL URL, should be published in IDMS. PKI system establishes a trust relationship between PDP, PAP and PEP components as shown in the following Figure 5.12.

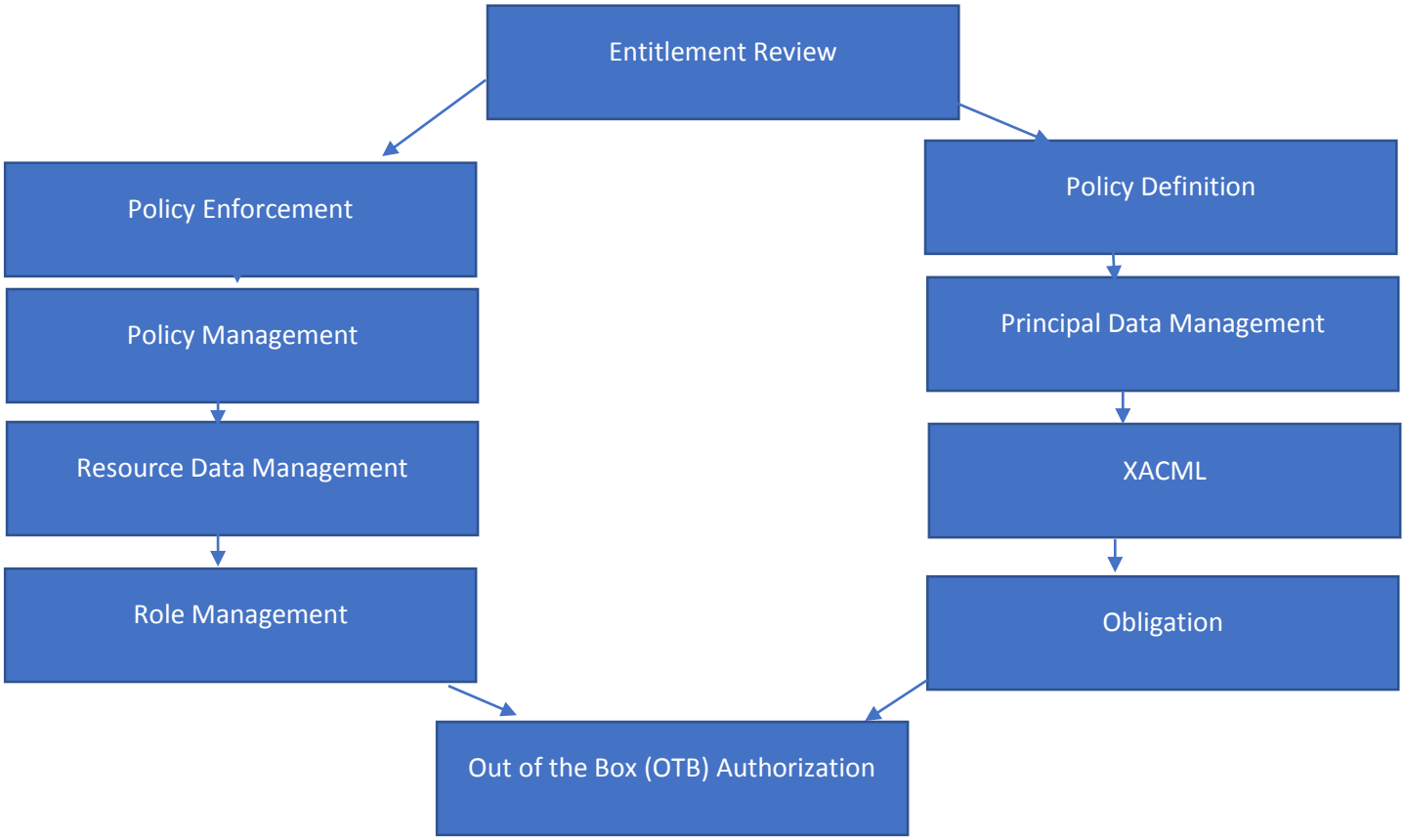


Figure 5.12 Authorization Standards for MSL Framework

Entitlement Review	Comparing an authorized entity's granted access rights to the business responsibilities of that entity to ensure least privilege is being followed. In order to increase efficiency of the attestation process, the asset owners can be aided with information associated to the risk of each entitlement (additions, deletions, changes of roles or accounts that are associated to entities with increased risk or security incidents).
Policy Definition	A phase, in Authorization services, where access is authorized**.**
Principal Data Management	The capability for the management of all attributes regarding the subjects of access control decisions. These principals can be users, machines, or services. Authorization decisions may need to consider many attributes about the principles including role, location, relationships to accounts other principals, etc.
XACML	eXtensible Access Control Markup Language is a declarative access control policy language implemented in XML. As part of identity management, standards like the eXtensible Access Control Markup Language (XACML) can be used by a cloud provider to control access to cloud resources, instead of using a proprietary interface. XACML focuses on the mechanism for arriving at authorization decisions, which complements SAML's focus on the means for transferring authentication and authorization decisions between cooperating entities.
Obligation	In XACML an obligation is a directive from the Policy Decision Point to the Policy Enforcement Point on what action must be completed before or after an access is granted.
Out of the Box (OTB) Authorization	A method that allows authorization to be externalized from applications, for example by providing an authorization plug-in. This allows developers to avoid expense and trade-offs of creating custom access control. OTB Authorization solutions can provide full featured authorization that includes a complete RBAC model, policy storage, user interface, built in application group support,

	rule and query support, integrated system auditing, and performance optimization.
Policy Enforcement	A phase, in Authorization Services, where access requests are approved or disapproved.
Policy Management	A process or platform for centralized policy creation, repository and management.
Resource Data Management	Authorization plays a key role in data management by simultaneously providing access and protection to application information resources.
Role Management	A role represents a set of permissions and privileges and role management assures that roles are properly defined to include only the required permissions and privileges and that they are properly assigned to entities.

Table 10 Authorization Standards Mechanism in the Proposed MSL Framework

5.8.7 Security of Incident Management and Reporting Standards

The next major adoption challenge to the cloud computing is the response to the incident management and how to report the problems. As there was absence of any standards and no SLA to address this issue, it was considered as a major barrier to the adoption of cloud technology according to the literature review. The information security incident is an event or a series of unwanted security events that can compromise the business operations and threaten the information security. The information security incident management are the processes for detecting, reporting, assessing, responding to, dealing with, and learning from information security incidents. The standards are required for cloud providers to ensure consistency in the security incident management. At present there is no standards of how information security incidents are handled and how quickly there will be resolution of an incident by a cloud service provider is a great concern to cloud service customers. The proposed MSL framework provides a mechanism which is as follows that details the timely reports incidents to customers, the cloud provider is bound to timely respond to each incident and cloud provider should resolve these incident in a restricted time as detailed in the Figure 5.13. The proposed MSL framework set standards and strict time for estimated response time for reporting the incident to customer, timely incident response and timely incident resolution as shown in the following figure. The Table 11, provides a detailed classification of incidents in the proposed framework and Table 12 explains the KPIs in the proposed framework.

Figure 5.13 Incident Management and Reporting Standards

Classification for Incidents

Priority	Classification for Incidents	Guidelines for Reporting Incident	Estimated Response Times
P1	Critical Priority – Severe Breach, System Down	Produce Incident Report – Communicate with all Cloud Users instantly.	**Inform Affected Cloud Users** 0-30 minutes **Initial Target Response** 0-1 hours. **Incident Target Resolution**: Priority reduced to P2 within 0-3 hours.
P2	High Priority – Degrade the performance of Functions.	Produce Incident Report – Communicate with the Cloud user	**Inform Affected Cloud Users** – 1-2 Hours **Initial Target Response**: 1-2 Hours **Incident Target Resolution**: Within 8 Hours priority reduced to P3
P3	Medium – Standard Functionality Issues	Produce Incident Report – Communicate with the Cloud user	**Inform Affected Cloud Users** Weekly Report **Initial Target Response**: Within 24 Hours **Incident Target Resolution:** Within 24-48 Hours Priority reduced to P4

P4	Low Priority – Minor Issues with the cloud system.	Produce Appendix Incident Report – Communicate with the Cloud user	**Inform Affected Cloud Users** Monthly Appendix Report Initial Target Response: Within 48 Hours Incident Target Resolution: Within 48-72 hours. Priority reduced to P5 status
P5- Normal Status No Incident Reported			

Table 11: Classification for Incidents

Critical	**P1- Critical Priority: System Down, Major Breach**
High Priority	**P2- High Priority: Degrade the performance of Various Functions.**
Medium Activity	**P3-Medium: Standard Function/ Processes affected. Can lead to P2 if not resolved.**
Low Priority	**P4- Low Priority: Minor Issues with the cloud system. Best standard practice to resolve within time limit**
Normal	**P5-Normal: Normal Status No Incident Reported**

Key Factors	Description
% of Timely Incident Report	Percentage by the number of defined incidents reported within a predefined time limit after discovery, over the total number of defined incidents to the cloud service which are reported within a predefined period (i.e. month, week, year, etc).
% Of Timely Incident Response	Percentage by the number of defined incidents assessed and acknowledged by the cloud service provider within a predefined time limit after discovery, over the total number of defined incidents to the cloud service within a predefined period. (i.e. month, week, year, etc)

% Of Timely Incident Resolution	Percentage of defined incidents against the cloud service that are resolved within a predefined time limit after discovery.

Table 12 KPI (Key Performance Indicators) of Incident Resolution

5.8.8 Interoperability and Portability Standards

The next major adoption challenge to the cloud computing is the interoperability and portability standards. The issues with legacy system, moving data between different cloud service provider and issues such as lock-in are considered as a major barrier to the adoption of cloud technology. As there was absence of any standards and no SLA to address this issue, it was considered as a major barrier to the adoption of cloud technology according to the literature review. Cloud interoperability means that data can be processed by different services on different cloud systems through common specifications. Cloud portability means that data can be moved from one cloud system to another and that applications can be imported and run on different cloud systems at an acceptable cost. The interoperability allows exchange, use of data and services among various cloud infrastructure offering and to use the data and services exchanged to enable them to operate effectively together. In the proposed MSL framework, Figure 5.14, interoperability and portability standards ensures portability and interoperability standards as shown from the following figure. The standards that are recommended are as follows:

- Hardware should be virtualized and physical security control established to remove any concern;
- All network devices are virtualized to be shared easily;
- Use the open standard for virtualization such as VMware;
- Open APIs should be used to facilitate migration of data;
- Set procedures for data storage should be adapted in which store unstructured data in a portable format, encrypt data while it is stored or on transit, and ensure to use computable database;
- Provide security of the data using SAML or WS-Security for authentication, encrypt data before sending to cloud, log files are encrypted and key secure storage and access policy.

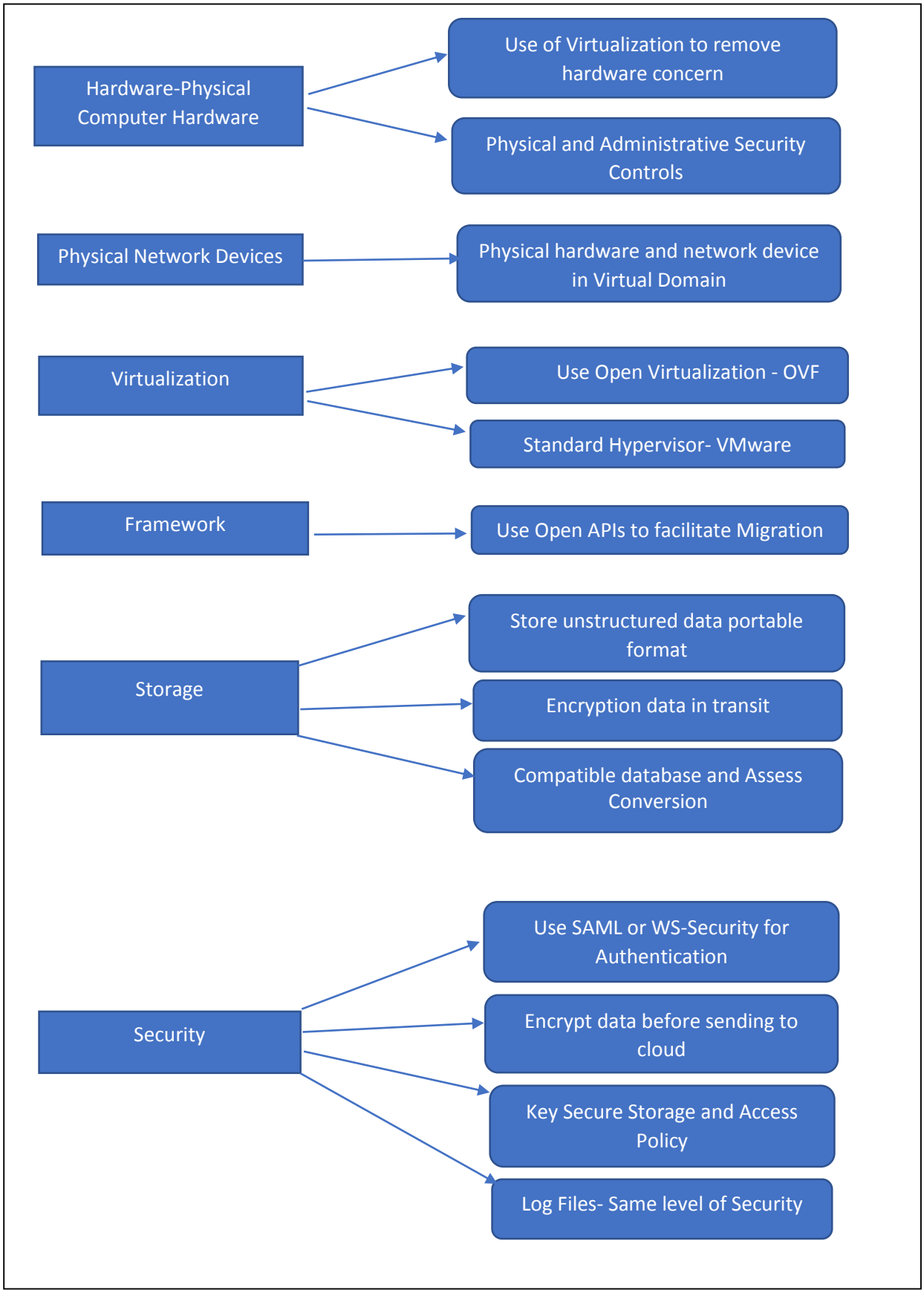


Figure 5.14 Interoperability and Portability Standards in the MSL Framework

5.8.9 Identity Management Standards

The proposed MSL framework introduces identity management standards with the use of the Domain Unique Identifier as shown in the following Figure 5.15 (Identity Management standards) which is a unique reference number used as an identifier in computer software (for example GUID, 32-character hexadecimal string), used for Microsoft's implementation of the Universally unique identifier standard. This is required for Identity Management standards used in the proposed MSL framework. The proposed MSL framework to ensure Identity Management standards uses Federated IDM, which provides a directory services that secures user access to network resources with the ability to setup a trust relationship between various security domains to enable the passing of authentication, authorization and privacy assertions. The proposed framework uses Identity provisioning and attribute provisioning to secure user access to network resources, creation, maintenance and deactivation of user objects as they exist in one or more systems, directories as shown from the following figure.

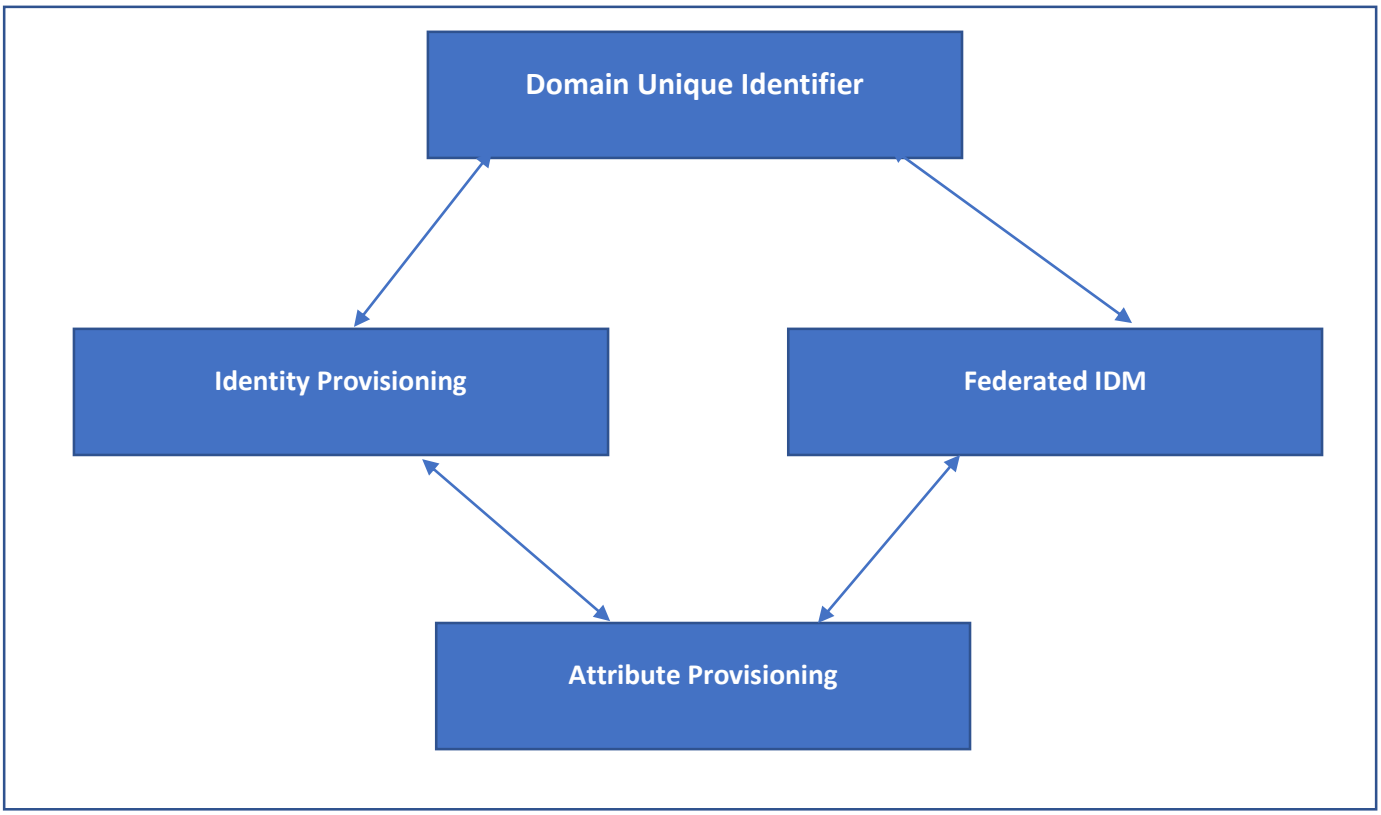


Figure 5.15 Identity Management Standards in Proposed MSL Framework

Domain Unique Identifier	A unique reference number used as an identifier in computer software (for example GUID, 32-character hexadecimal string, used for Microsoft's implementation of the Universally unique identifier standard).
Federated IDM	Refers to a new standards based approach to directory services that streamlines and secures user access to networked resources, with the ability to establish trust relationships between various security domains to enable the passing of authentication, authorization and privacy assertions.
Attribute Provisioning	Refers to a new standards based approach to directory services that streamlines and secures user access to networked resources, with the ability to establish trust relationships between various security domains to enable the passing of authentication, authorization and privacy assertions.
Identity Provisioning	The creation, maintenance and deactivation of user objects as they exist in one or more systems, directories or applications, in response to automated or interactive business processes

Table 13 Identity Management Standards

5.8.10 Privilege Usage Management Standards

The next major adoption challenge to the cloud computing is the privilege usage management standards and the access rights to its users. As there was absence of any standards and no SLA to address this issue, it was considered as a major barrier to the adoption of cloud technology according to the literature review. The proposed MSL framework introduces the mechanism of Privilege Usage Management Standards as shown in the Figure 5.16 by storing the key stroke and session logging mechanism for capturing a detailed record of interactions with an entity (either at the level of individual keystrokes or interactions with the entity). The proposed mechanism uses the password vaulting solution, by introducing a software based solution to securely store and manage multiple passwords.

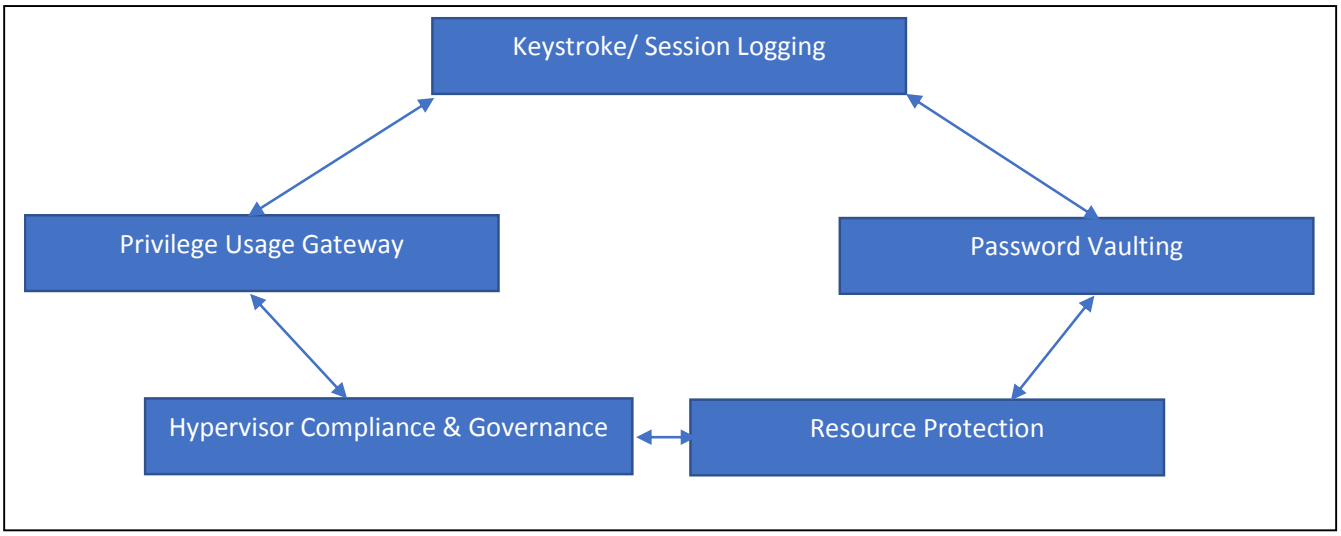


Figure 5.16 Privilege Usage Management Standards

The proposed MSL framework recommends to use Hypervisor Compliance and Governance standard which gives the capability of privilege management and monitoring by role. The user associated to hypervisor administrators, this also includes management of virtual network, servers, and applications on a cloud environment as explained in the following Table 14**.**

Keystroke/ Session Logging	Methodologies for capturing a detailed record of interactions with an entity (either at the level of individual keystrokes or interactions with the entity).
Password Vaulting	A software based solution to securely store and manage multiple passwords.
Resource Protection	Detailed Policy to protect all your resources.
Hypervisor Compliance and Governance	The capability of privilege management and monitoring by role and user associated to hypervisor administrators, this also includes management of virtual network, servers, and applications on a cloud environment.
Privilege Usage Gateway	A gateway to grant/deny connection for sessions based on usage privilege on that workload**.**

Table 14 Privilege Usage Management Standards

5.8.11 Infrastructure Protection Services Standards

The proposed MSL framework provide the mechanism to secure the infrastructure by securing the cloud servers, end-points, networks and applications address the adoption challenge of infrastructure security. The recommendation to secure the infrastructure are detailed in the following Figure 5.17, to ensure security for cloud provider and cloud users. The server should use the behaviour malware prevention strategy that provides the ability to identify behaviour of malware based on events. For example, inbound email with attached targeted malware to be filtered via the use of a secure virtual machine to identify when the payload is triggering atypical activity. The end-points used in the cloud provider should have the following features such as anti-virus, host firewall, deployment HIPS/HIDS, whitelisting the devices, media lockdown and use of hardware based trusted asset.

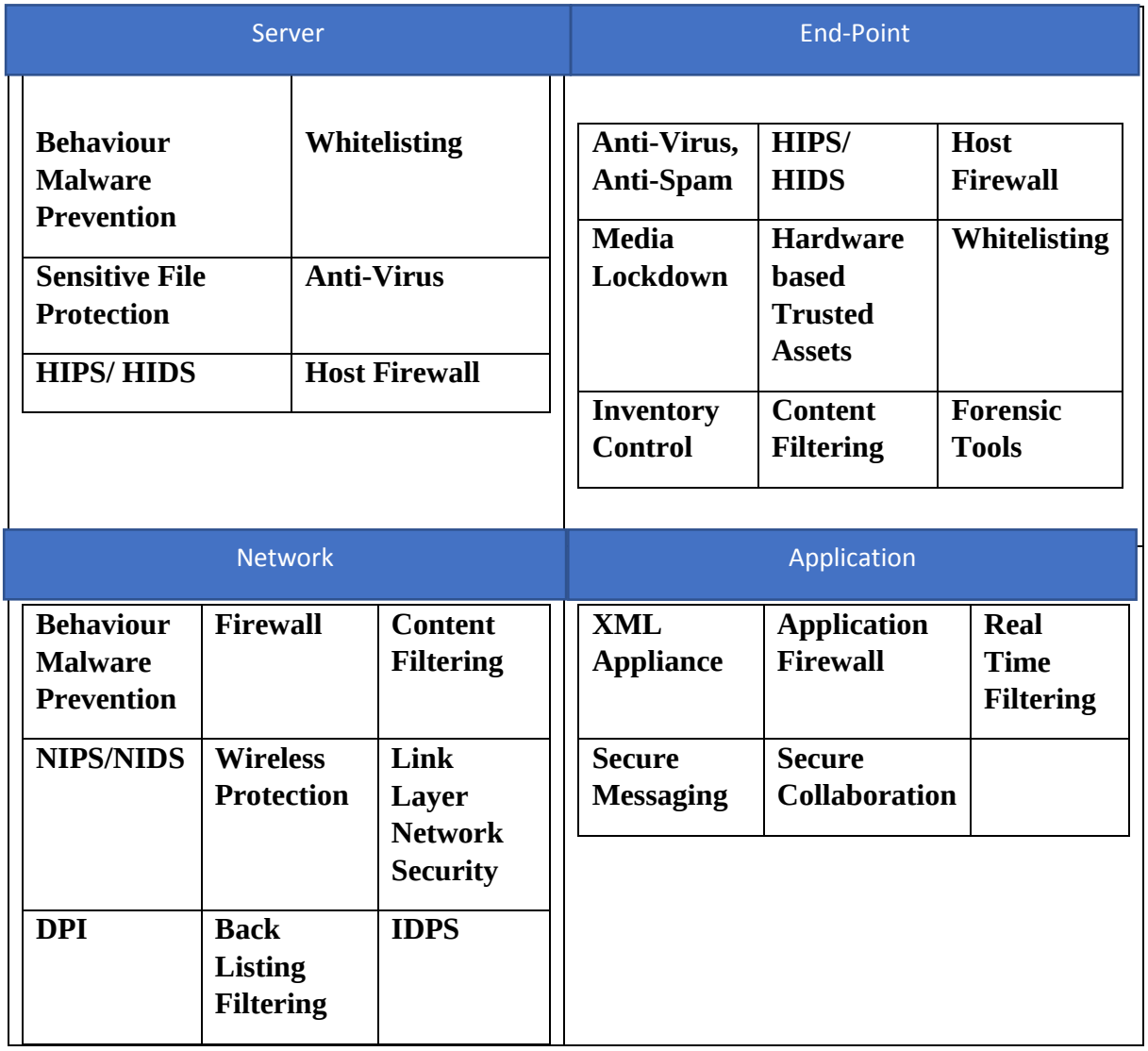


Figure 5.17 Infrastructure Protection Services Standards for MSL Framework

5.8.12 Develop Governance Management and Compliance Process Standards

The proposed MSL framework recommend to develop a Governance Management and Compliance Process standards. The framework ensure the compliance with all specified internal information security policies, control standards and defines a detailed policy management with primary objectives of the security program. This policy management defines the standards to maintain an organization structure and process that supports the creation, implementation, exception handling and management of policy that represent business requirements. The proposed MSL framework details the policy related to the vendor management, audit management, provide technical training and awareness and compliance standards as mentioned in the following table 15.

Compliance Management	Analyses compliance with all specified internal information security policies, control standards and procedures.
Policy Management	Security policies are the primary objectives of the security program. Policy management strives to maintain an organization structure and process that supports the creation, implementation, exception handling and management of policy that represent business requirements.
Vendor Management	Ensure that service providers and outsourcers adhere to intended and contractual information security policies applying concepts of ownership and custody.
Audit Management	It must be possible for an independent auditor to verify that the system conforms to the security policy. To enable this, systems and processes need to be in place that record security related events in a tamper-resistant audit log.
Technical Awareness and Training	To increase the ability to select and implement effective technical security mechanisms, products, process and tools.
Period Assessment of Achieved of Cloud Services Levels against CSA	Reports from cloud service provider of cloud service levels. Monitoring reports on cloud service usage created by customer cloud service administrators.

Periodic Assessment of Compliance of Cloud Services	Where the compliance of the cloud service to specific standards or regulations is important to the customer, it is necessary for the customer's governance process to periodically check that the cloud service still has valid proof of compliance.
Service Failure Report	Reports of any service failures or incidents which affect: • Service availability • Security, particularly security breaches • Protection of personal data
Notification of Change from Cloud Service Provider	Any change notifications from the cloud service provider which relate to the cloud services being used (change of APIs, change of functionality, change of service level objectives, change or cloud service pricing, change of terms in the CSA).
Key Indicator Report	Four key indicators should be tracked to ensure that the CSA criteria are being met and that the downstream users of the service (either internal or external to the enterprise) are experiencing the level of service that has been agreed to: • High impact problems and time to resolution • Number of open problems and their respective impact • Total view of problems not resolved within agreed to time frames • Trends of number of problems being reported with the resulting resolutions
Problem Report	In order to ensure CSA compliance, a set of reports needs to be produced. Reports that focus on the current reporting period addressing: • All problems reported (sorted by impact) • Problems closed (sorted by impact) • Duration of open problems (sorted by impact)
Request Report	Reports on (non-problem) requests made by the cloud service customer to the cloud service provider: • All requests made • Number of open requests • Time to action requests
User Satisfaction Report	Reports on user satisfaction with the cloud service(s)

Escalation Process Standards	
Consideration	**Description**
Objectives	Raise management awareness to avoid surprises (gives the perception that senior management is in control of the situation). • Gain agreement for action plans to resolve a problem. • Develop either a plan and gain agreement for additional resources, when required.
Guidelines	Problem has a critical impact to the overall business to either an internal service or a customer facing service. • Service is still available but is significantly degraded; potential impact to a customer facing service. • Problem is of a significant impact and has missed the agreed to targets for resolution. • Independent of impact, problems are not being closed within the expected guidelines. • Number of problems is increasing with no agreed to resolution to reverse the trend. • Requests to the cloud provider to participate in root cause analysis or problem resolution in an associated system or tool are ignored.
Types	Immediate: • A critical business impact is identified • Significant impact to a customer facing service **As required**. Typically after a review when: • The duration of problem resolution is not being met. • Number of open problems exceeds expectations. • Trend for reported problems is increasing without a satisfactory resolution plan being offered.

Table 15 Governance Management and Compliance Process Standards in the Proposed MSL Framework

5.8.13 Data Management Service Level Standards

The proposed MSL framework provides data classification standards for cloud service customer data, the classification of cloud service provider's data and derived data should be classified in the proposed framework as shown in the following table 16.

Data Classification

Cloud Service Customer Data	Data should be classified as customer and stated policy for any intended use of cloud service customer data.
Cloud Service Provider Data	Data related to the provider should be classified separately.
Cloud Service Derived Data	Describes what derived data is created by the cloud service provider from cloud service customer data, the intended uses for the derived data and what rights the cloud service customer has to inspect the derived data.

Table 16 Data Management Service Level Standards of MSL Framework

5.8.14 Data Mirroring, Backup and Restore

The proposed MSL framework introduces data mirroring, backup and restore strategy as detailed in the following table to enhance data backup and restoration services in the proposed framework. As suggested in the proposed framework data mirroring will be used with 15 minutes RPO (Return Point Objective) and Return Time Objective (RTO). The proposed framework defines the data backup method with the use of Full Time and Incremental backup deploying RAID10. The proposed MSL framework also introduces the use of backup generators, 30 minutes to restore the cloud users' data and data should be successful restored by 99.95% with the backup strategy deployed as shown in the table 17.

RPO (Return Point Objective)	15 Minutes RPO – Data Mirroring should be done. Data Mirroring for both transient and persistent data. Also backup and redundancy should be in place.
RTO (Return Time Objective)	15 Minutes RTO.
Latency	Storage and the time the same data is placed on mirrored storage.
Data Backup Method	Refers to a list of method(s) used to backup cloud service customer data. Full Time Backup – Incremental Backup with RAID10.
Data Backup Frequency	Refers to the period of time between complete backups of cloud service customer data.

Backup Generators	Refers to the number of backup generators available for use in data restoration. Must Install a backup Generators.
Backup Retention Time	Refers to the period of time a given backup is available for use in data restoration. Backup retention time defined as per industry requirements.
Maximum Data Restoration Time	Refers to the committed time taken to restore cloud service customer data from a backup. Maximum 30 minutes.
Percentage of Successful Data Restoration	Refers to the committed success rate for data restorations, expressed as the number of data restorations performed for the customer without errors over the total number of data restorations, expressed as a percentage. Percentage of Successful data restoration should be minimum of 99.95%.

Table 17 Data mirroring, backup and restore standards in Proposed MSL Framework

5.8.15 Data Life Cycle

The proposed MSL framework defines the data deletion type and defines the percentage of timey effective deletion of data in Table 18. The SLA are designed in the proposed framework to address the data storage and its deletion life cycle.

Data Deletion Type	Describes the quality of data deletion, ranging from 'weak' deletion where only the reference to the data is removed, to 'strong' sanitization techniques to ensure that deleted data cannot be easily recovered.
Percentage of timely effective Deletion	Refers to the number of cloud service customer data deletion requests completed within a predefined time limit over the total number of deletion requests, expressed as a percentage.
Percentage of tested storage retrievability	Refers to the amount of cloud service customer data that has been verified to be retrievable during the measurement period, after the data has been deleted.

Table 18: Data Life Cycle in the Proposed MSL Framework

5.8.16 Data Portability

The proposed MSL framework defines that data should be in a portable format and provides the ease of moving data from one platform to another platform as mention in the Table 19 Data Portability in the Proposed MSL Framework.

Data Portability Format	Specifies the electronic format(s) in which cloud service customer data can be transferred to/accessed from the cloud service.
Data Portability Interface	Specifies the mechanisms which can be used to transfer cloud service customer data to and from the cloud service. This specification potentially includes the specification of transport protocols and the specification of APIs or of any other mechanism that is supported.
Data Transfer Rate	Refers to the minimum rate at which cloud service customer data can be transferred to/from the cloud service using the mechanism(s) stated in the data interface.

Table 19 Data Portability in the Proposed MSL Framework

5.8.17 Data Protection

In order to protect the data, the proposed MSL framework proposes the following features to be adopted by the cloud provider. The metadata should be controlled by defining the metadata accompany the underlying data (e.g., the record of changes to a document maintained as metadata by a word processing application should not be released with the document). As mentioned in the Table 20, the proposed MSL framework recommends the use of data masking by obscuring (masking) specific data elements within data stores. It ensures that sensitive data is replaced with realistic but not real data. Also introduces data tagging in which metadata is tagged to a piece of information. It helps describe an item and facilitates it being found again by browsing or searching. The proposed MSL framework also recommends the use of electronic signature is a means of indicating that a person adopts the contents of a digital data or that the person who claims to have written a message is the one who wrote it. This is most frequently used on unstructured data as suggested in the table 20.

Data Life Cycle Management	
Meta Data Control	Controlling what types of metadata accompany the underlying data (e.g., the record of changes to a document maintained as metadata by a word processing application should not be released with the document).
Data De-Identification	The process for removing identifying information from datasets, most commonly to protect the privacy of individuals, by using methods such as data masking. Data de-identification may also be used to protect organisations, such as businesses included in statistical surveys, or other information such as the spatial location of mineral or archaeological finds or endangered species.
Data Masking	The process of obscuring (masking) specific data elements within data stores. It ensures that sensitive data is replaced with realistic but not real data. The goal is that sensitive customer information is not available outside of the authorized environment.
Data Tagging	A data tag is a keyword or term assigned typically as a form of metadata to a piece of information. It helps describe an item and facilitates it being found again by browsing or searching.
E-signature (Unstructured Data)	An electronic signature is a means of indicating that a person adopts the contents of a digital data or that the person who claims to have written a message is the one who wrote it. This is most frequently used on unstructured data.
Life Cycle Management	Policies, processes and procedures for managing the lifecycle of data from creation through use, archiving and eventual destruction.
Data Obscuring	A method of protecting fields or records of data by some form of obfuscation such as encryption. Data obscuring techniques can be used in source code for example to prevent reverse engineering of applications.

	There are also low tech solutions such as ink stamps to redact sensitive information on hardcopies.
Data Seeding	A way of detecting and tracking data scraping, plagiarism, and theft is to seed the data with either easily identifiable items in order to trace where the data ends up or with bogus records in order to destroy the value of the data. For example, by inserting a record in a database of phone numbers with an odd name, the true originator/owner could identify that bogus record if it appears in a competitor's database.

Table 20 Data Protection Mechanism in Proposed MSL Framework

5.9 Summary

As the cloud computing is gaining popularity both organizations and users are having problems to adopt cloud services due to poor and variable QoS standards. Various concerns have been raised recently such as data security and privacy concerns, variable level of service offered by different providers, poor interoperability, issues related to data integrity, accountability, identity management concerns, weak audit mechanisms and vague guidelines for data protections and regulatory framework, response mechanisms and lack of guidance and user feedback support mechanism. The above issues can be seen as the major requirement and need to be addressed to improve the adoption rate of cloud computing technology so the researcher proposes Minimum Service Level (MSL) framework model to the cloud industry. This model also addresses the concerns raised during the literature review which were faced in the adoption of cloud technology. The framework provides minimum standards for a set of key services which are crucial to cloud users and can provide better QoS and standards. The framework will remove any ambiguity, confusion and resolve the legitimate concerns of the cloud users which will result in the improvement of adoption of cloud services across the industry. The framework will allow to compare and evaluate the level of services offered by various cloud providers that will ease the selection process of the cloud provider and set minimum standards for the cloud providers to be achieved. This framework will act as a benchmark to improve the overall QoS and all providers will be held accountable according to the proposed framework which will improve the overall standard of services and competition in the cloud industry.

Chapter 6. Research Methodology

6.1 Introduction

As the cloud computing is gaining popularity organizations and users are having problems to adopt the service due to lack of minimum service level framework which can act as a benchmark in the selection of the cloud provider and provide quality of services according to the users expectations. The situation becomes more critical due to distributed nature of the service provider which can be offering service from any part of the world. There are serious concerns and challenges related to lack of uniform standards or nonexistence of minimum benchmark for level of services across the industry to provide an effective, uniform and reliable service to the cloud users. In order to investigate the problem further different research methodologies approaches such as Qualitative, Quantitative and mixed approaches will be discussed and after the discussion a particular approach will be used in this particular research. The research will be based around the HE institutions in the specific case study.

The qualitative approach according to (Wolcott, 1994), explains general statements and tries to establish relationships between these themes. The approach included data collection followed by the interpretation of the data to improve the understanding of the problem and explain the concepts more clearly for the audience (Huberman and Miles, 2002). According to the authors the approach promotes the questioning of the data as different ideas are emerged that forms new entities or categories to establish the theme. The author further explains the qualitative approach allow themes to be generated within the data and then initial coding system can be used to represent that data. This approach allows to analyse, compare and establish similarities and differences through the data and key themes to identify the direction of the research. This approach can provide verification of results through the triangulation approach which will establish the relationship between each themes and provide a detailed understanding and knowledge about the problem which is being investigated (Huxham and Vangen, 2000). Whereas quantitative approach investigates and identifies the problem more precisely by measuring the magnitude of relationships more precisely (Creswell, 1998). The approach uses the experimental or correlational design methods to remove any ambiguity, reduce the chance of error and provide a very clear picture. For this research various methodologies will be discussed and compared in the following chapter

followed by the justification of which approach will be used in this research. The chapter will also discussed the research approach and design elements of the research with detailed explanation to ethical consideration and other key issues that were considered to ensure that the data gathering exercise is authentic, original and verified in the current research.

6.2 Research Philosophies

In the following section different research approaches and philosophies are discussed which were considered during the detail literature review and data collection stage. First of the approach considered was the epistemological approach which is a part of philosophy that asks questions such as "what can we know?" or "what can we be sure of?" and questions such as "how do we get beyond opinions and data to the real facts and knowledge?". According to (Creswell, 1998) an epistemology approach is important because it is fundamental to how we think. The author further explains it by stating that without some means of understanding how we can acquire knowledge, how we rely upon our senses and how we develop concepts in our minds, we have no coherent path of thinking that is available. A sound and stable epistemology approach is essential for the existence of sound thinking and reasoning this is the main reason why so much of philosophical literature can involve so much of discussion about the nature of knowledge. As stated by (Huberman and Miles, 2002) one of the main entities of the approach is rationalism that is a reason when this method makes claim to truth the reasoning should be logical and consistent. The approach relies on the results and typically time tested results considered more authentic. While scientific methods base their claims in controlled experiments, the approach pragmatic view derives conclusion via practical life experiences. The epistemological approach basis for this research project is a combination of realism and interpretivism. As reinforced by (Huxham and Vangen, 2000), in practice it is rare that a particular research questions sits so neatly into the one philosophical area and that is the case here.

The interpretivist approach is another useful approach to covert the patterns of causal connections. The approach can be used to find more variables and their relationships. The philosophical approach is that the critical realist side to the research for example what is known about the relationships between the concepts of the framework is fine but never

provides the reasoning why there is a relationship. As stated by (Hunt, 1999) states “the approach provides a paradigm.... that serves to define what should be studied, what questions should be asked, what rules should be followed in interpreting the answers obtained. The paradigm is the broadest unit of consensus within a science and serves to differentiate one scientific community from another”. The interpretivist approach is arguable well suited to the social sciences giving credence to the understanding of the themes according to (Parry, 1998). In consequence it has less stringent claims of causation (Pearce and Conger, 2002). The approach sees the result of research as an individual interpretation of fact, based firmly on a systematic approach to analysis and the maintenance of an open mind according to the authors. However the basis of interpretation leads to the potential for researcher bias; no matter how rigorous the methods, the researchers may still look predominantly for what he wants to see.

The positivist research paradigm places emphasis on the precise measurement of the phenomena; within the context of this study it is unlikely that a precise measurement can be achieved given the exploratory nature of the research problem. The post positivist paradigm also relies on a tendency to measure and it does acknowledge that social reality can only be explained imperfectly (Shank, 2013). The study aim does not seek to challenge prior critical paradigm nor does it seek to develop new relationship in this regard to the art or the sciences of research. So for this reason critical and post-modern paradigms are perceived as unsuited for the study. The realistic objectivity is based around what is known about the key function in the specific HE institution case study, its strategy, formal structure and systems that managers have to work within and what could be considered as constants. The subjective entities of the conceptual framework such as quality of services offered by cloud technology in the HE institution are not easy to measure and are not fixed or constant. They can only be fully understood through interpretivist means as this part of the conceptual framework assumes that reality is not always observable and in this instance that is very much dependent on the Quality of Service (QoS) Standards and a uniform service level model that can guarantee a certain level of services. Using the approach the proposed conceptual framework that offers a minimum service level framework of cloud users and set standards for cloud providers can be implemented in the specific HE institution.

6.3 Comparison between Qualitative, Quantitative and Mixed Method

According to (Yulk, 2015) in social sciences quantitative research is often contrasted with qualitative research which is the examination, analysis and interpretation of observations for the purpose of discovering underlying meanings and patterns of relationships. The qualitative research does not involve mathematical models although, it has been argued again and again that the two go hand in hand. Some writers always argue that there was a disagreement about the proper place of qualitative versus quantitative research. The new method of qualitative research evolved to address the perceived problems with reliability and imprecise modes of data analysis. Both the research methodologies have a different assumption about the world. According to (Wolfe and Smith, 2007) quantitative research is based on a positivist philosophy, which assumes that there are social facts with an objective reality apart from the beliefs of individuals. Qualitative research is rooted in a phenomenological paradigm, which holds that reality is socially constructed through individual or collective definitions of the situation. The second major comparison between both the approaches was done perfectly by authors where the writers explains that quantitative study portrays a world of variables and static states whereas qualitative study describes people acting in events or a program. The writer gave an example of how director tells using hiring interviews to encourage staff to actively sell services or an informant tells about the political battles that led to the legislation governing sales. The writer further argues that differences presented between qualitative and quantitative studies having different descriptive strengths.

The quantitative study assesses the magnitude of relationships more precisely. One can say rather clearly that 61% of the variance in student learning is explained. The qualitative study concludes with more ambiguous statements like "strong leadership is necessary, but not sufficient for excellence." The author highlights the issues with the implementation of the approaches regarding these research methodologies where the quantitative researcher typically employs experimental or correlational designs to reduce error, bias, and other noise that keeps one from clearly perceiving social facts. The prototypical qualitative study is the ethnography, which helps the reader understand the definitions of the situation of those, studied. The author investigate the issue of purpose regarding the research methodologies where quantitative research seeks to explain the causes of changes in social facts, primarily through objective measurement and quantitative analysis. Qualitative research is more

concerned with understanding the issue and viewpoints. (Pope and Mays, 2016) emphasis that quantitative study persuades by de-emphasizing individual judgment and stressing the use of established procedures. While the language of hypothesis testing is avoided, the impression is given that the whole study is a disciplined exploration of a pre-existing conceptual framework where is qualitative study there is less attention is given to describing procedures and how individual judgment is disciplined in the qualitative study. The study is presented as frankly exploratory. The strategy is one of comparing pairs of agencies known to be different in order to discover what might explain those differences. The search is not described as strongly controlled by pre-existing theory. There is no preliminary model, instead, reference to past research is incorporated into the presentation of findings.

Quantitative research designs are characterized by the assumption that data, evidence, and rational considerations shape knowledge (Bayya, 2009). Qualitative research designs are those that are associated with interpretative approaches, from the informants' point of view, rather than ethically measuring discrete, observable behavior. The author explains that neither quantitative, nor qualitative method, however, is superior over the other, for each has its own strengths and weaknesses, especially when considered in relation to a particular problem. (Bryman et al, 1996), however, mentions that there is some polarity between the two methods; where quantitative approach is described as hard, objective, and rigorous; the other is considered to be soft, subjective, and speculative. At the same time, many researchers have shown that both the approaches may complement each other and may be integrated in the practice of social research.

Mixed methods research has thus come of age (Creswell, 1998). The most widely used term given to the concept, encompassing use of more than one method employed within one piece of research, is triangulation between methods. As seen from the Figure 6.1, whilst not arguing for a hierarchy of research methods, this third way, the mixed methodology, provides even greater strengths to the researcher, and may enhance both the quality and the perception by others, of the research. The study involved both secondary as well as primary research and concurrent triangulation approach can be adopted. It is useful as a model when a researcher uses two different methods in an attempt to confirm, cross-validate, or corroborate findings within a single study. Creswell also emphasizes that this model generally uses separate

quantitative and qualitative methods as a means to offset the weaknesses inherent within one method with the strengths of the other method.

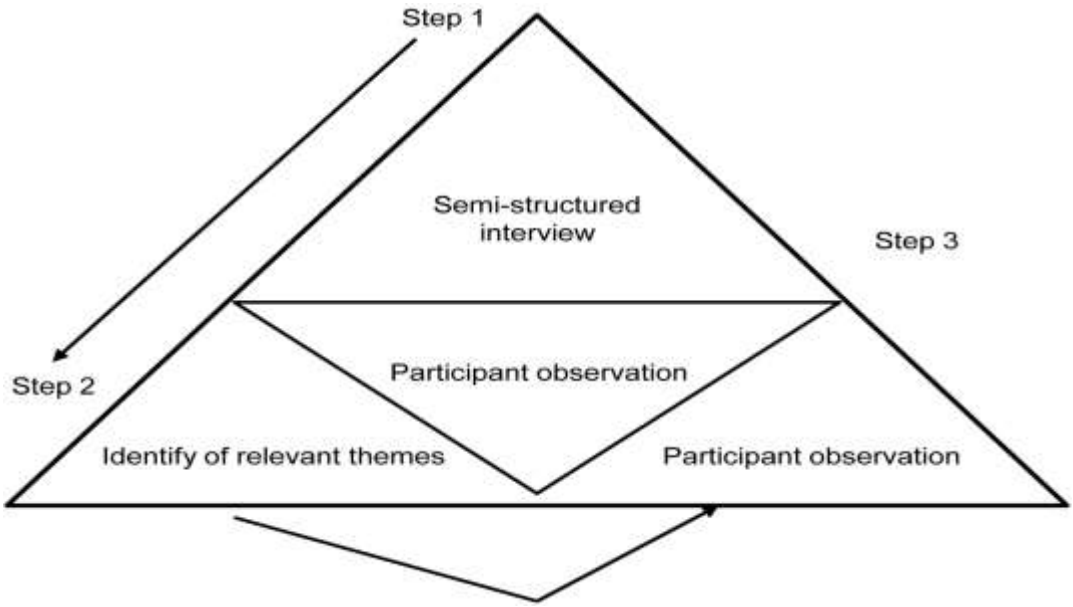


Figure 6.1 Qualitative and Quantitative Triangulation Method (Strauss, 1990)

6.4 Research Strategy: Justification of Methodology

The study is an effort to explore the barriers in the smooth adoption of cloud computing technology and its problem in the day-to-day working in the HE institution due to lack of framework or mechanism that can act as a benchmark to the quality of service (QoS) standards and provide uniform level of service regardless of their hosting location. The research will provide analogy by comparing the views and experiences of students, staff, senior management and technical support team to identify the key barrier in the adoption and usage of cloud computing technology in the HE institution and how we can address to these barriers. This approach will collect information qualitative in nature, rather than any numerical collection of data or explanation based on the attributes of the graph or source of data. As reinforced by (Shank,2013), qualitative research is often used for policy and current working procedures since it can answer certain important questions more efficiently and effectively than quantitative approaches. Qualitative approaches have the advantage of allowing for more diversity in responses as well as the capacity to adapt to new developments or issues during the research process itself so it would be more suitable to use in the research project to investigate the current problem. So qualitative methodology would be more suitable as reinforced by (Yulk, 2015) where author highlights the difference between two methodologies where the

quantitative researcher typically employs experimental or correlational designs to reduce error, bias, and other noise that keeps one from clearly perceiving social facts. The prototypical qualitative study is the ethnography, which helps the reader understand the definitions of the situation of those, studied. The qualitative study is more concerned with the understanding of the issues and viewpoints of the people and issues related to them.

The study is based on the specific HE institution case study that has implemented the cloud computing technology to support their day to day working. According to (Schall, Ospina and Dodge, 2002), case study approach will enable a holistic account of the subject, which will help to investigate and explore relationships between the experiences of students against the staff, management and technical support team while adopting and using the cloud computing services. The study will try to answer the questions whether the expectation and motivation of different stakeholders at the HE institution were met with the implementation and usage of cloud computing technology in the HE institution? What are issues related to the quality of services and standards that the end-users are facing with the usage of cloud technology? Did the main stakeholder (students and staff, management and technical support team) agreed or disagreed on the benefits, key barriers and problems in the adoption and usage of cloud computing technology and services in the HE institution? Were key players able to carry out their duties with the implementation of the new technology or due to any barriers there were problems? What were the underlying reasons if there are any issues or barriers to the successful adoption and implementation of cloud computing technology in the HE institution? How we can address any barriers to the adoption of the cloud technology so that the adoption of the technology can be increased across HE institutions?

This is particularly the case for understanding how and why certain outcomes were achieved (not just what was achieved) but also answering important questions about the key requirements in order to provide better quality of service to the users in the HE institution. This will be achieved by using questionnaire from the students and staff. These types of research can be expensive and time-consuming to conduct, many fields of research employ qualitative techniques that have been specifically developed to provide more succinct, cost efficient and timely results. For this research, a specific HE institution case study is used which provide a single case holistic approach. The research is focused on investigating adoption of cloud

technology its benefits and any barriers preventing successful implementation of cloud computing technology? The research will try to explore what challenges which are faced in the adoption of the technology and does cloud industry has a mechanism for the selection of the cloud provider or making them accountable to its cloud users? Is there a need of a mechanism or framework that can act as benchmark which provides guarantee in terms of cloud computing services? The other major reason of using the specific case study is, that we can collect multiple views from different stakeholders, which are involved in the organisation. The multiple views from different students, staff and management can give a detailed insight about the organization and allow the researcher to understand fully the issues related to the research topic.

One more key benefit of using the case study is that it provides easy approach to the students and staff to get their opinion and then to broaden the knowledge after the questionnaire then involve the experiences of staff and management with the questionnaire to understand the underlying key issues and barriers that are effecting the adoption and smooth implementation of cloud computing technology in the HE institution. The main drawback with a single case study is that it does not allow any sort of comparison or critical evaluation of responses from other research case. This can be limited if the research wants to draw conclusion from another case study.

6.5 Research Strategy for the Specific Case Study

The following section will discuss the strategy and analysis process that has been formulated and will be used in the research. The analysis process describes the basic elements of data analysis and interpretation and its results. First of the research is based on a specific HE institution case study which will provide a holistic account of the issues related. The case study approach will allow to understand the overall situation and have a sound knowledge how these entities interact with each other and their relationship. The specific HE institution have deployed the cloud computing technology and the researcher will investigate the advantages of the technology and whether it meets their expectation? Also the research will focus on the adoption barrier to the use of technology and now with the implementation whether the technology meets the target audience expectations and organizations goals and objectives.

To gain detail understanding of all the issues around the barriers in the adoption and implementation of cloud technology in the HE institution this can only be achieved using semi-structured interviews and qualitative questionnaires due to time constraints and the limited access time to the target audience in the case study. The research is not looking to compare the individual student against each other or compare different departments against each other. The main focus of the study is to consider students and staff as a single entity or element and identify and explore the barrier in the overall usage of cloud computing technology in the HE institution. Then the senior management will be asked about the key barriers in the adoption and usage of cloud computing technology and services in the HE institution. These difference of experiences and opinion will be compared and contrasted to find the real problem in the adoption of cloud technology. Also apart from the survey questionnaires, interview will be conducted with the senior management, technical staff and academic staff to have a detailed view about the adoption of cloud technology and if they have any adoption challenges in the implementation or the usage of the technology in the HE institution.

The methodology, which will be employed, in this research will draw the existing knowledge, utilizing the conceptual model and the most crucial is the researcher's experience working in this cloud computing industry will be very useful. Currently the researcher is working for HE (Higher Education) Institution in UK which is trying to implement the cloud computing technology to improve its operations and take advantage of the technology. In order to conduct the research, the researcher will use different strategies to collect data from different sources and triangulate them to verify the authenticity of the data. For this research the researcher will design detailed survey questionnaires that will be directed towards the students at the HE institution to explore their experience in the usage of cloud computing technology in the institutions and any issues or challenges they have faced (See Appendix A1 for the used questionnaire). After the data is collected from the students, the detailed questionnaire has been conducted with the academic staff, senior managers and technical support team to investigate and compare the views and experiences from of using cloud computing technology in the HE institution. The data collected from this target audience was used so we can compare it with the data collected from the students. The questionnaire is available in the Appendix A-II. The interview will be used to collect a detailed opinion from

the senior management, academic staff and the technical support team which will be analysed in detail. The interview is available in the Appendix A-III.

The good analysis of data depends completely on understanding the data that has been gathered and having in depth knowledge about the issues related to the problem that is being investigated. During the qualitative analysis the data gathered should be studied in detail and also any noticeable impression should be recorded which can be further investigated from different focus groups of students, staff, management and technical support team. The focus should be on the quality of data because sometimes information provided does not add any meaning or value. The process of detailed evaluation and analysis will lead to what you want to find out. This will identify few key questions that you want your analysis of the research to answer. This will be noted and help to decide how to begin. The key questions can change but the focus will be maintained. In this approach the focus will be to analyse how individuals or focused group responded to each question. This stage will be crucial because all the responses will be collected in order to identify the consistency and differences. The data from each question will be put together. Then the researcher will explore the connection and relationships between questions and their responses collected. During different research various methods are used to categorize information such as coding the data or indexing the data. To bring the real meaning to the data collected different key themes or pattern will be organized based on ideas, concepts, behaviours, interactions or key phrases. Then organization into coherent categories will be summarized and bring meaning to the text. This process can be very time consuming and labour intensive depending on the amount of data that will be collected. The process has to be thorough and the data collected will be reread multiple times to identify the coherent categories or key themes. The key themes will get the focus of the study and areas that need further investigation. In the research using the preconceived themes or categories, you read through the text and find the themes or issues that recur in the data. This approach allows the categories to emerge from the data. These categories or key themes are defined after you have worked with the data or as result of working with data. The initial list of categories can change as you work with the data and investigate further. This is an iterative process and some new themes can emerge or different subcategories can emerge to get the focus.

As you are organizing the data into different key themes and categories either by the questions you will begin to see the key pattern and connections both within and between the key themes. Assessing the relative importance of different themes will be crucial for the analysis of data. To identify which categories appear to be more important, you can count the number of times particular themes comes up, or the number of unique respondents who refer to certain themes. These count can provide a very rough estimation of relative importance of key themes. Also, during the analysis of data we can find that two or more themes that can occur together consistently in the data. When one theme is found the other appears automatically. It can be cause and effect relationship or create sequence through time. For example, respondents may link that the barriers to the adoption and implementation of cloud technology in the HE institution because of certain reason whereas another focus group repeat the same shows the cause effect relationship. These connections, if identified, are important to look for, because they can explain why something is happening and helps to identify the problem and better understanding of the underlying issues. Then the researcher should ask himself how do things relate with each other? What are the key themes and what relationship they have with each other? What can be other factors that may contribute? Then they key themes and connections will explain the findings. The researcher will avoid to get side tracked by the details and the rich description in the data and focus on the important issues and key relationships that are being investigated in the research. The interpretation of data will take place provide meaning and significance to the analysis of data. The good place to initiate is to develop a list of key points or important findings that will be discovered as a result of categorisation of key themes and sorting the data. Then the next phase of analysis of data is to stand back and think about what you have learned. What are the major lessons? What new things that have been learnt due to the process? In the final part of the analysis development of an outline presenting the results and writing the final report. The report can include quotes or descriptive examples to illustrates the points and bring the data to real existence. The length and format of the report will depend on the target audience. Sometimes to support the description of the information different diagrams with boxes and arrows can fit all the pieces together. By creating models may reveal gaps in your investigation and connection that remain unclear. These areas can be investigated for further study.

6.5.1 Selection of Research Methods

In order to investigate the study; research methods, which will be used, are as follows:

- The research is divided into two groups of the target audience. One group consist for 100 students and the second group consist of academic staff, senior management, technical support team consisting of 45 members;
- Initially the questionnaire with focus groups of students and groups 2 consisting of staff, senior management, technical support team will be conducted separately. The data collection exercise is conducted via a series of focus group (10 participants in each focus group. Total 100 participants in the students group and 45 participants in the staff, management group). The total sample consist of 145 individuals;
- Each questionnaire with each of the focus group is designed to last for 60 minutes and taken place on these dates 24/11/2017, 05/12/2017, 07/12/2017, 12/12/2017, 14/12/2017, 03/01/2018, 04/01/2018, 05/01/2018, 09/01/2018, 12/01/2018, 16/01/2018, 20/01/2018, 25/01/2018, 26/01/2018, 30/01/2018, 01/02/2018, 02/02/2018, 06/02/2018, 08/02/2018, 09/02/2018, 10/02/2018;
- Students are selected from the IT/ Computer Science departments with wide range of experiences and different level of qualifications and expertise;
- Majority of students are in the final year of the degree program whereas there is a major portion of respondents from the post graduate as well;
- The data collection exercise was be conducted at the premises of the HE institution;
- During the semi-structure interview the key areas that need further explanation were highlighted and asked from different focus group to get their opinion. Also opinion from the senior executives, technical support team and academic staff were collected using interview as well;
- The themes needing further explanation were conducted using telephonic interviews and emails;
- To compare and contrast the view, the same set of questions related to key themes were be asked from the both the focus groups (students and staff);
- Open Ended questions were asked at the start of the investigation phase so that participants can feel relax;
- Documentation related to contractual agreement of the cloud provider has been reviewed.

Different authors and writes agree in the literature that using semi-structure interview would allow in the future to investigate more areas as they gather probing replies. This was reinforced by (Shank, 2002) questionnaires offer consistency in lines of enquiry with the ability to offer opportunities for further probing responses. The methods have been deployed in different researches and have earned credibility in different qualitative research. To ensure credibility of the research and data which is collected, is verified using different multiple methods and sources are used. These multiple methods will allow triangulating of the facts, which have been gathered. In the study the data from the previous chapter in the literature review will be compared against the focus group questionnaire data and further consolidated and checked during detailed questionnaire from the academic staff and senior management team. The themes that need further investigation the researcher will conducted detailed interview to explore and find more information regarding those areas. This will ensure all facts gathered are authentic and valid. In-order to receive a detail feedback from the data collection exercise open ended questions will be used followed by multiple choice questions where multiple answers are entered based on the priority. Also using focused group will encourage all the participants to think about different emerging themes discussed and it will build on relevant themes. To follow up on different themes and issues raised during the focus group, will be investigated further. The literature review will form the foundation of the questionnaires, interviews that will be conducted in the research.

6.6 Data gathering Strategy

In order to collect data for this research a detailed questionnaires were designed for each participants refer to (Appendix 1-4). In the research we have target audience which was divided into different groups such as Academic Staff, Senior Management, Technical Support Team and Students. The purpose of this investigation is to present the results of data collected in this study to highlight the adoption barrier to the cloud computing in the specific case study HE institution. The research data will highlight the concern regarding the implementation of cloud computing in the HE institutions and identify what aspects should be improved in the day-to-day working of cloud computing in the HE institutions. In order to collect the response from the HE institutions both qualitative and quantitative strategy will be used. To the start the process initially a Questionnaire will be used to collect data from the students and staff at the HE institutions and collect their opinion about issues and concerns regarding the implementation of cloud computing in the HE institutions and what students

and staff, thinks should be done to improve the quality of standards that will address the adoption barriers. The survey is anonymous, voluntary response, based on the multiple choice model, and with questions in a closed format are used. The version of the survey is a test to evaluate the comprehension, validation of the questionnaire and allow corrections for subsequent application to the target audience. After the data collected from the questionnaire a detailed interview will be conducted by the senior management, academic staff, and technical team to collect the point of view and adoption barriers to the implementation of the cloud computing in the HE institutions. The qualitative data will be gathered after the detailed interview process and following the ethical guidelines the names of all respondents will be hidden. All responded will be represented by a unique code. The qualitative statement of similar nature will be grouped together and different theme statement will be shown separately for each question.

6.7 Summary

The research is based on a specific HE institution case study which will provide a holistic account of the issues related. The case study approach will allow to understand the overall situation and have a sound knowledge how these entities interact with each other and their relationship. The specific HE institution have deployed the cloud computing technology and the researcher will investigate the advantages of the technology and whether it meets their expectation? Also the research will focus on the adoption barrier to the use of technology and now with the implementation whether the technology meets the target audience expectations and organizations goals and objectives. To gain detail understanding of all the issues around the barriers in the adoption and implementation of cloud technology in the HE institution this can only be achieved using semi-structured interviews and qualitative questionnaires due to time constraints and the limited access time to the target audience in the case study. The research is not looking to compare the individual student against each other or compare different departments against each other. The main focus of the study is to consider students and staff as a single entity or element and identify and explore the barrier in the overall usage of cloud computing technology in the HE institution. Then the senior management will be asked about the key barriers in the adoption and usage of cloud computing technology and services in the HE institution. These difference of experiences and opinion will be compared and contrasted to find the real problem in the adoption of cloud technology. Also apart from the survey questionnaires, interview will be conducted with the senior management, technical staff and academic staff to have a detailed view about the adoption of cloud technology and if they have any adoption challenges in the implementation or the usage of the technology in the HE institution.

Chapter 7. Presentation and Analysis of Data

7.1 Introduction

Cloud computing ensures parallel computing and emerged as an efficient technology to meet the challenges of rapid growth of data that we experienced in this Internet age. Cloud computing is an emerging technology that offers subscription based services, and provide different models such as IaaS, PaaS and SaaS to cater the needs of different users groups as stated by (Manuel, 2016). The technology has enormous benefits but there are serious concerns and challenges related to lack of uniform standards or nonexistence of minimum benchmark for level of services across the industry to provide an effective, uniform and reliable service to the cloud users. As the cloud computing is gaining popularity organizations and users are having problems to adopt the service due to lack of minimum service level framework which can act as a benchmark in the selection of the cloud provider and provide quality of services according to the users expectations. The situation becomes more critical due to distributed nature of the service provider which can be offering service from any part of the world. Due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the industry there are serious concerns raised recently in security and data privacy breaches, authentication and authorization problems, lack of third party audit and identity management issues, integrity and variable availability standards, confidentiality and no uniform incident response and monitoring standards. This research examines the adoption barriers to the cloud computing due to the absence of MSL (Minimum Service Level) Framework and proposes a conceptual model based that acts as benchmark for the industry to ensure quality of service to the cloud users. The proposed framework act as a set of minimum standards to be provided by the cloud provider which eases the selection of cloud provider and act as a benchmark to make them service provider accountable for quality of service offered. The MSL framework, proposes a set of minimum and uniform standards in the key areas which are essential to the cloud users and provide a minimum quality benchmark that becomes a uniform standard across the industry.

7.2 Cloud Computing Adoption Challenges

In this section of the chapter the researcher will provide a brief overview of the adoption challenges faced by the potential cloud users. There are challenges before and after the

implementation of cloud computing technology. The term “Cloud Computing” is defined by the National Institute of Standards and Technology (NIST) as “a model or enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, server, storage, applications, and services) that can be rapidly provisioned and released with minimal effort or service provider interaction” according to (NIST SP 800-145, 2011). In the last many years, the computation has experienced enormous changes from centralized to distributed system and now moving back to the centralization as a structure. The benefit of the cloud computing services are many where the model significantly cut IT infrastructure costs and this saving can be used for operational expenses, also model provides on demand access to vast IT resources that are available in the cloud. The rapid growth of data which we have experienced in this Internet age, the capacity of normal PC cannot meet the demand of large scale massive data scientific computing. The model with its benefits have lots of concerns which have been raised. This model leaves the client/customer not aware of where the data is stored or how it is maintained. Due to the design of the model the client or customers has lack of or no control over their data and where Internet is used as a communication media to access data.

The security, confidentiality, integrity and availability of the data in the cloud computing is a major adoption barrier and the provider has to provide concrete assurance in terms of service level agreement (SLA) to assure the customer regarding the data protection and privacy issues according to (Clark, Warnier and Brazier, 2016). The increase of public cloud providers, cloud consumers face various challenges such as data security and privacy issues, authorization and authentication breaches, poor availability standards, lack of interoperability and response time standards, methodology to allocate resources, weak or no third party audit mechanism and lack of monitoring and responses standards. For cloud industry it is not possible to fulfil all the customers’ expectations where service providers are offering different quality of service and there is no framework to benchmark the services offered by these various cloud providers. The non-functional requirements such as availability, confidentiality, integrity, scalability, response time, reliability, third party audit, governance issues and monitoring and response mechanism are crucial to the cloud consumers to ensure better quality of service. In order to protect and provide privacy to the data the new privacy framework has been recently initiated known as GDPR (General Data Protection Regulation) that provides a new policy to deal with the challenges of privacy of the data in the information society. The regulation (EU) 2016/679, provides protection to process the

personal data and provides safeguards to the movement of such data within EU members. With the implementation GDPR, there are serious implications to the cloud providers and the overall industry. There is lack of uniform standards across the cloud providers in the industry. Due to lack of uniform standards, interoperability cannot be achieved across the cloud providers. The existing storage specification by a provider can be completely incompatible with the storage specification of the different cloud provider that can lead to interoperability issues. For e.g. if the cloud user want to move data from one provider to another there can be a situation that it is not possible due to lack of uniform standards. Data stored in Amazon's S3 is totally incompatible with IBM's Blue cloud or Google storage. There are serious implications for the cloud users as there are no uniform standards across the industry for cloud providers which can lead to less users opting for cloud option. The standards may be reused in the cloud but for the moment there are to our knowledge no dedicated minimal standards that provide a uniform service to the cloud users and acts as a benchmark to the quality of service offered by the providers. In the next section the research will apply the findings from the literature review into the specific case study HE institution to find the adoption barrier to the implementation of cloud computing technology and try to address these challenges so that the adoption of cloud technology increases.

7.3 Characterization of Interviews and Questionnaire

7.3.1 Purpose and Type of Interviews and Questionnaire

The purpose of this investigation is to present the results of data collected in this study to highlight the adoption barrier to the cloud computing in the specific case study HE institution. The research data will highlight the concern regarding the implementation of cloud computing in the HE institutions and identify what aspects should be improved in the day-to-day working of cloud computing in the HE institutions. In order to collect the response from the HE institutions both qualitative and quantitative strategy will be used. To the start the process initially a Questionnaire will be used to collect data from the students and staff at the HE institutions and collect their opinion about issues and concerns regarding the implementation of cloud computing in the HE institutions and what students thinks should be done to improve the quality of standards. The survey is anonymous, voluntary response, based on the multiple choice model, and with questions in a closed format are used. The version of the survey is a test to evaluate the comprehension, validation of the questionnaire and allow corrections for subsequent application to the target audience. After

the data collected from the questionnaire a detailed interview will be conducted by the senior management, academic staff, and technical team to collect the point of view and adoption barriers to the implementation of the cloud computing in the HE institutions. The qualitative data will be gathered after the detailed interview process and following the ethical guidelines the names of all respondents will be hidden. All responded will be represented by a unique code. The qualitative statement of similar nature will be grouped together and different theme statement will be shown separately for each question.

7.3.2 Interview Applied

The interview contains 9 questions that will require a response from the senior management, academic staff and technical support team. The purpose of the interview is to collect the management opinion in-detail about the issues and concern in the adoption of cloud computing in the HE institutions and what can be done to improve the process. The responded will be represented by a coding system for management team it will be MT, Academic team the code is AT and technical support team it will be TS. The responses gathered will be in the form of qualitative statements that will be written for each question. The following section detail all the format of the interview with the list of questions that were asked during the interview process.

7.3.3 Questionnaire Applied

The questionnaire contains 19 Questions which are divided into two questionnaire. The first questionnaire contains 9 questions that were investigated from the students at HE institutions whereas the second questionnaire contain 10 questions that were investigated from the staff, technical support team and management of HE institutions to investigate the key issues and challenges in the adoption and implementation of cloud computing in the HE institution. The following section will represent the findings for each questions separately. The start of the following section will highlight the adoption barrier mentioned by students during the data collection stage following by the data gathered from the staff, management and technical support team. The Table 21 shows the layout of the questions. Each question was designed in such a way that users will have a list of multiple choice options to select from each question. At the start of each questionnaire the users were given detailed explanation about the

technical term so they are aware of each term before completing the questionnaire. The users were briefed before they attempted to answer the questions.

Questionnaire from Student Target Audience

Issue Number	Number of Options	Type of response
1	**2**	**Only one option**
2	**2**	**Only one option**
3	**3**	**Only one option**
4	**14**	**Choose any number of option**
5	**8**	**Only 3 option**
6	**10**	**Only 3 option**
7	**10**	**Only 3 option**
8	**2**	**Only 1 option**
Question from Staff, Senior Management and Technical Staff		
1	**2**	**Only 1 option**
2	**8**	**Choose any number of option**
3	**10**	**Only 3 option**
4	**10**	**Only 3 option**
5	**2**	**Only 1 option**
6	**5**	**Choose any number of option**
7	**10**	**Only 3 option**
8	**10**	**Only 3 option**
9	**2**	**Only 1 option**

Table 21: Structure of the Questionnaire to the Target Audience

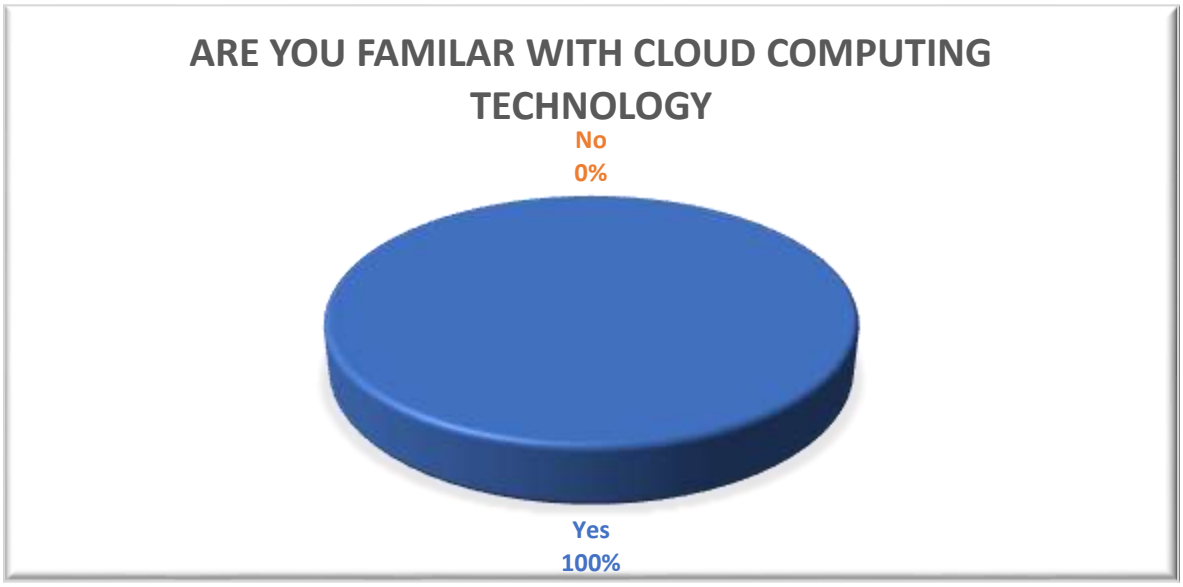
7.3.4 Results from the Questionnaire (Students)

From the initial investigation from the students at HE institutions the following preliminary data were obtained, whose answers are presented one by one questions in the tabular format and followed by the graphic representation so that it is easy for readers to understand the data collection. The questionnaire also have multiple choices that were allowed so that respondents can fill more than one answer for each question. These questionnaire were validated and the respondents were easily able to answer each questions.

Q1: Are you familiar with the cloud computing technology

In the response to the first questions that was asked from a group of 100 students there was an overwhelming response to the questions. The questionnaire was given out to a group of selected 100 students who were studying in the HE institutions. All respondents replied to the question where 100% confirmed that they are familiar with the "term" of cloud computing technology.

Sample Selected Population No	Number of Applied Questionnaires	YES	NO
100	**100**	**100**	**0**
		100%	**0%**

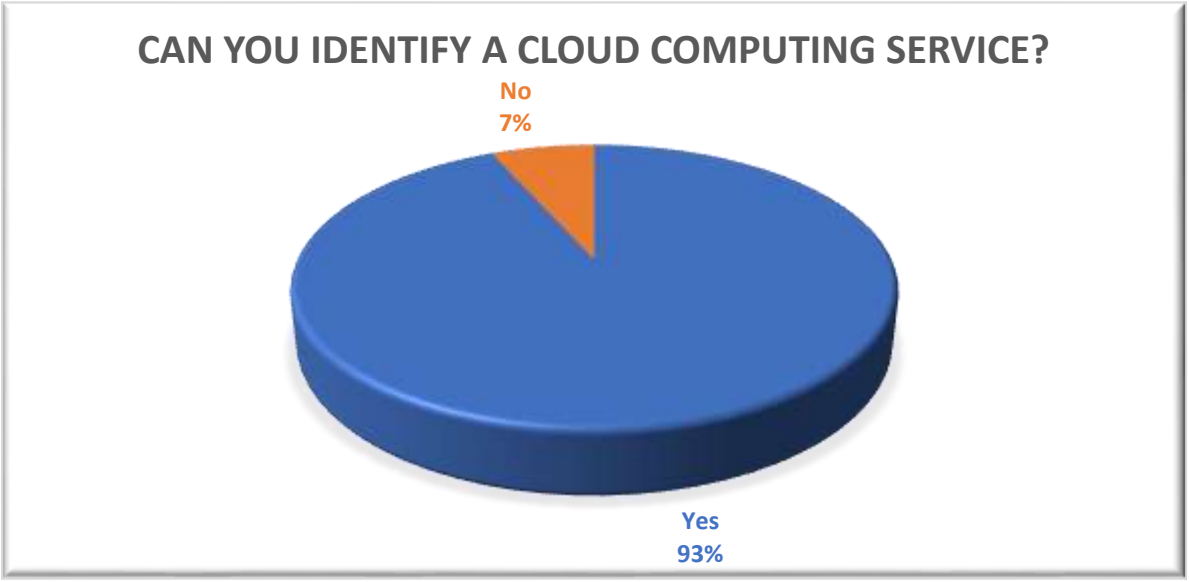


Graph 1 Familiarity of Cloud Computing Technology

Question 2: Can you identify a cloud computing service?

In the response to the second question that was asked from a group of 100 students all the respondents replied to the question. 93% of the respondents were familiar with one or more cloud computing services and how it is used currently whereas 7% of student respondents were not familiar with the cloud computing services and its application.

Sample Selected Population No	Number of Applied Questionnaires	YES	NO
100	100	93	7
		93%	7%

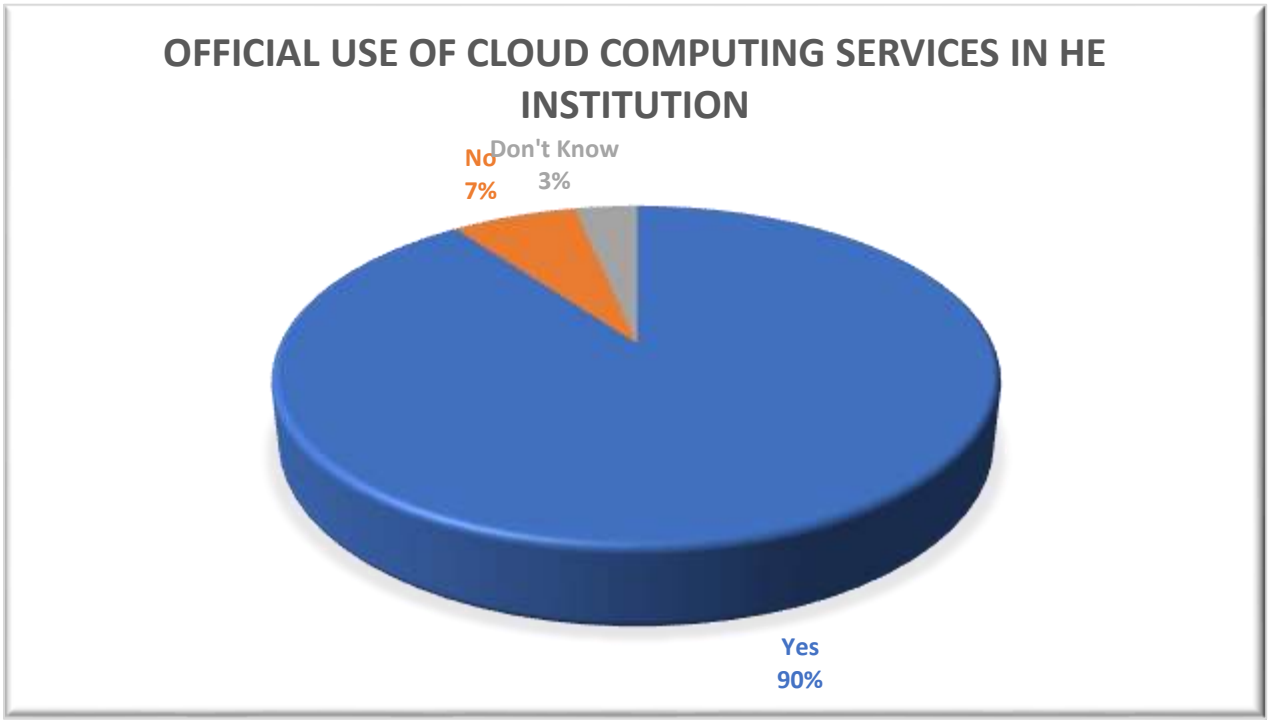


Graph 2 Identify Cloud Computing Service

Questions 3: Do you know whether your university is officially making use of third party cloud computing services?

In the response to the third question that was asked from a group of 100 students all the respondents replied to the question. 90% of respondents were aware that the HE institution were they are studying is using the cloud computing services whereas 7% of respondent stated that HE institution is not using a cloud computing technology and services in the HE institution. Only 3% of respondents replied as "don't know" as they are not aware whether the HE institution is using the cloud computing technology and services.

Sample Selected Population No	Number of Applied Questionnaires	YES	NO	Don't Know
100	100	90	7	3
		90%	7%	3%

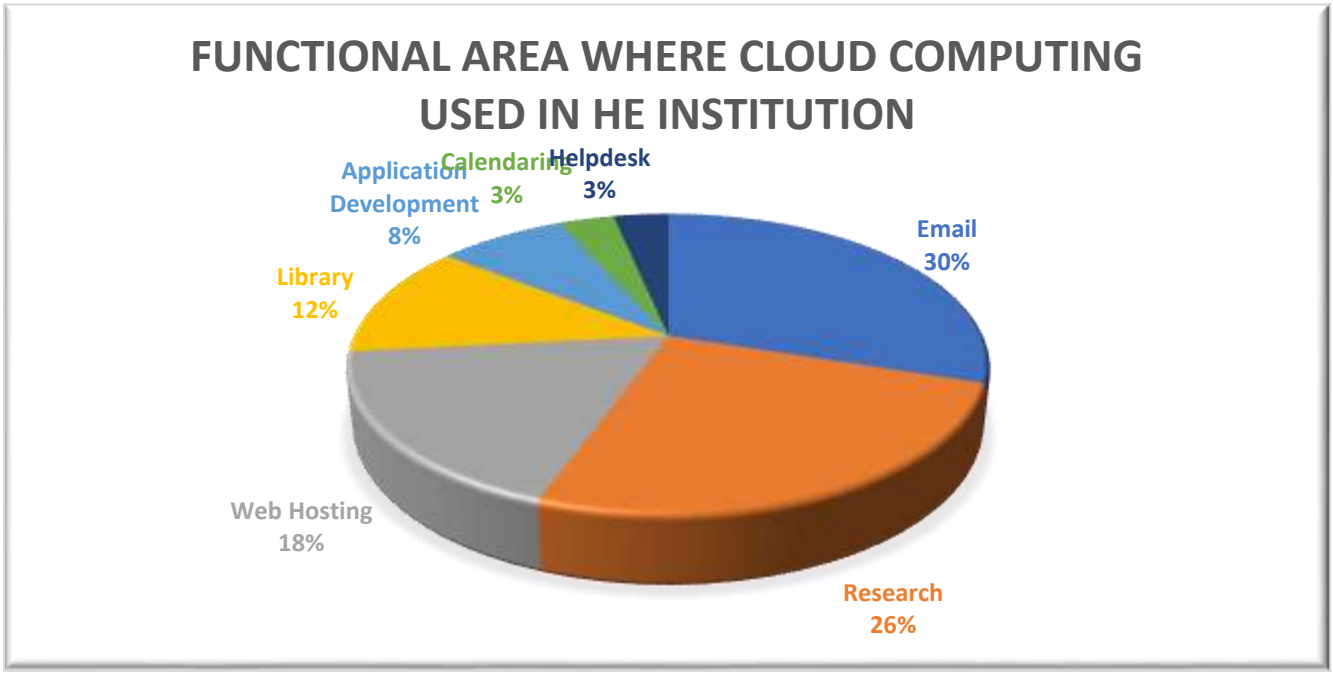


Graph 3: Use of cloud computing services in HE case study

Q4: Are you aware of the following functional areas does your university use third party cloud services? You may select multiple options if applicable.

In the response to the fourth question that was asked from a group of 100 students, 90 respondents were able to answer the question. 30% responded replied that Email is the functional area of the HE institutions that is using third party cloud services whereas 25.6% of respondents stated that the Research department is using the third party cloud computing services. According to 17.8% respondents, HE is using the cloud technology for web hosting service whereas 12.2% of the respondents stated that the library system in the HE institution is using the third party cloud computing services. 7.8% of respondent stated that Application Development functional areas is also using the third party cloud computing services followed by 3% respondents stated that calendar system and help desk is using the third party cloud computing services.

Sample Selected Population No	Number of Applied Questionnaires	Email	Research	Web Hosting	Library	Application Development	Calendar	Helpdesk
100	90	27	23	16	11	7	3	3
		30%	25.6%	17.8%	12.2%	7.8%	3%	3%

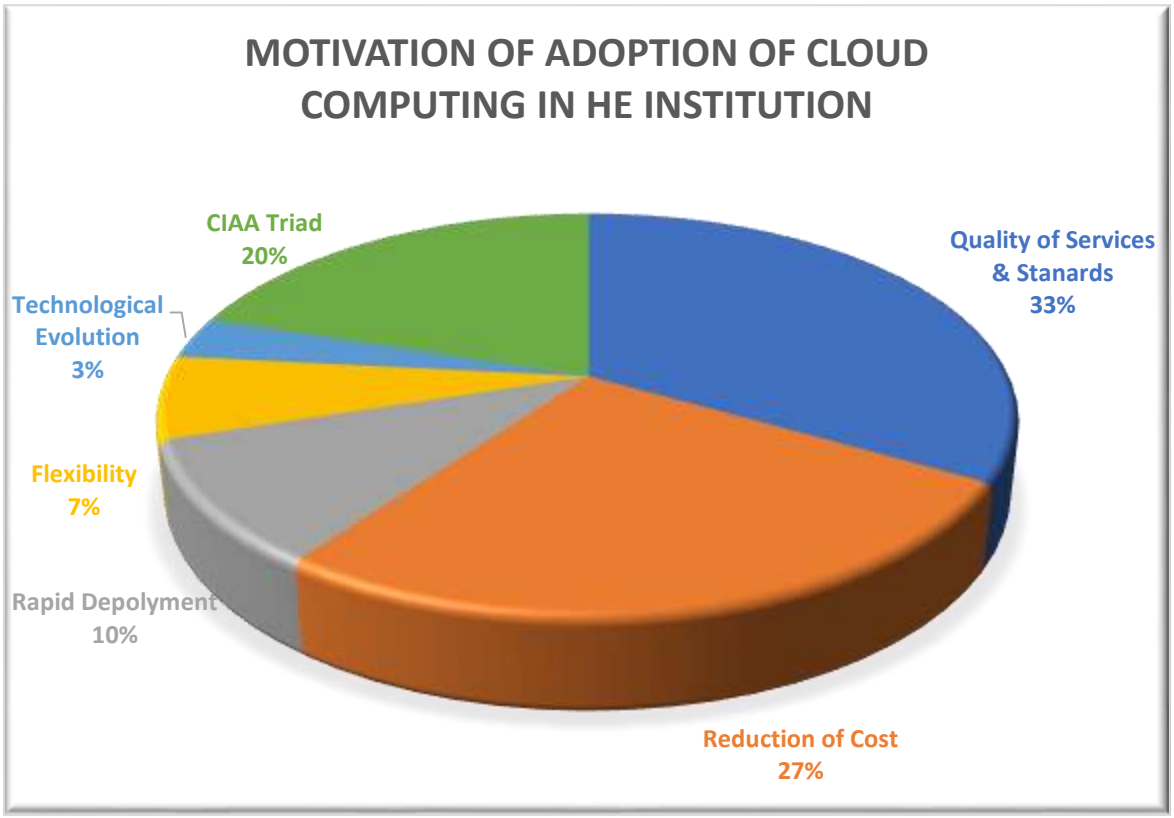


Graph 4 Functional area support by cloud computing technology

Q5: **What is your perception in the motivation for the adoption of Cloud Computing in HE institutions? Rank any following THREE in the priority by writing 1, 2, 3 in the option.**

In the response to the above question that was asked from a group of 100 students all respondents were able to answer the question. The question was trying to investigate the motivation to adopt third party cloud computing services and technology in the HE institutions. The overwhelming majority of the respondents 33% responded by stating that good Quality of Services (QoS) and Standards in the main motivation in the adoption of the cloud computing technology. This was followed by 27% of respondents agreed that cost reduction is the main motivating factor in the adoption of third party cloud computing services in the HE institutions. 20% of the respondents stated the CIAA Triad was a major factor in the adoption of cloud computing services in the HE institution followed by 10% of respondents agreed that rapid deployment of cloud computing services in the HE institution is the motivating factor in the adoption of the service. Only 7% of respondent believed flexibility followed by 3% stated technological evolution as a motivating factor in the adoption of cloud computing services in the HE institution.

Sample Selected Population No	Number of Applied Questionnaires	Quality of Services and Standards	Reduction of Cost	CIAA Triad	Rapid Deployment	Flexibility	Technological Evolution
100	**100**	**33**	**27**	**20**	**10**	**7**	**3**
		33%	**27%**	**20%**	**10%**	**7%**	**3%**



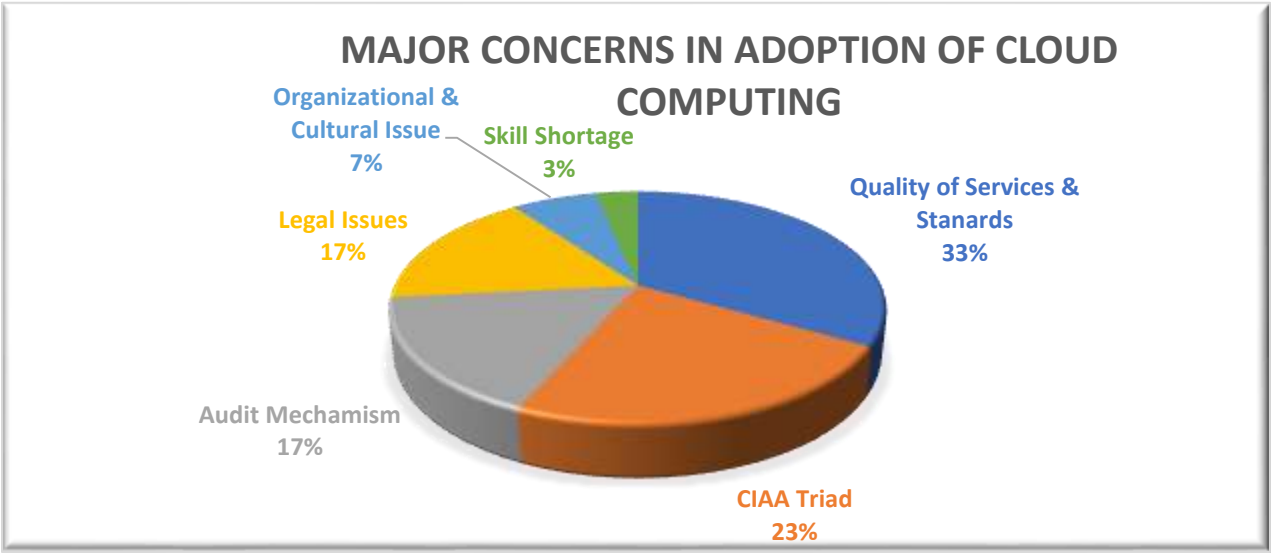
Graph 5 Motivation of adoption of cloud computing in case study

Q6: What you consider as a main concerns regarding the use of cloud computing in the HE institution? Rank any following THREE in the priority by writing 1, 2, 3 in the option.

In the response to the above question that was asked from a group of 100 students all respondents were able to answer the question. The major concern that was highlighted by the majority of the responded 33% indicated that lack of Quality of Services (QoS) Standards is the main concern in the use of cloud computing services in the HE institution. The second major concern that was highlighted by the respondents was regarding the CIAA triad as 23% were able to share their concerns while using the cloud technology in the HE institution. The next major concern that was highlighted by 17% of the respondents was poor third party Audit and Compliance issues. Also 17% of the respondents were worried with the legal implication of the use of cloud computing in the HE institution and considered this as a major barrier to the adoption of the technology. 7% of respondents raised organizational and

cultural issues while 3% raised skill shortage as a major concern in the use of cloud computing services in the HE institution.

Sample Selected Population No	Number of Applied Questionnaires	Quality of Services and Standards	CIAA Triad	Audit and Compliance Mechanism	Legal Issues	Organizational and Cultural Issues	Skill Shortage
100	100	33	23	17	17	7	3
		33%	23%	17%	17%	7%	3%



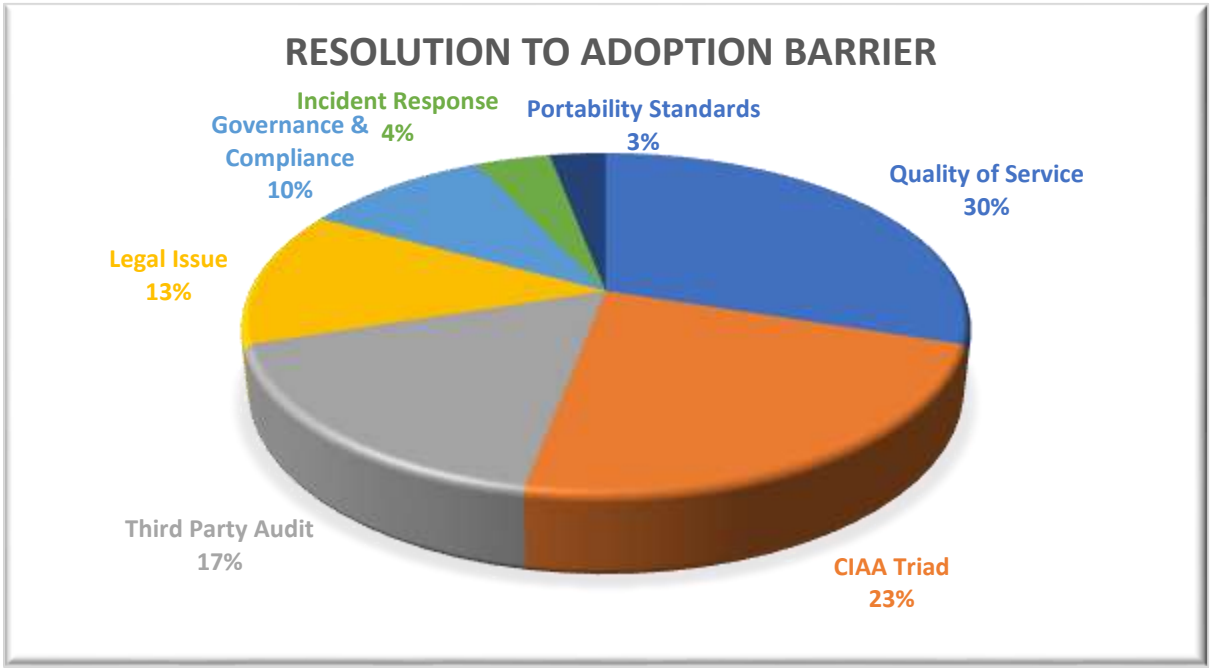
Graph 6 Major concern in the adoption of cloud computing technology

Q7: **What aspects of cloud computing you think should be improved to resolve the adoption barriers and challenges of cloud technology in the HE institution? Rank any following THREE in the priority by writing 1, 2, 3 in the option**

In the response to the above question that was asked from a group of 100 students all respondents were able to answer the question. 30% of respondents agreed to address the adoption barriers to the cloud computing technology and ensure the smooth implementation of technology in the HE institution; it is better to have some standards or a framework on Quality of Service (QoS) that is uniformly agreed across the cloud computing market. The next factor that will ensure the smooth adoption and use of cloud computing technology in the HE institution was ensuring and guarantying the CIAA Triad that was agreed by 23% of the respondents followed by 17% of respondent think that third party audit mechanism is required to improve the adoption barrier to the cloud technology in the HE institution. 13% of

respondents agreed that clarification and integrating the legal and compliance issues whereas 10% of respondents agreed that a comprehensive governance and compliance management can address the adoption barriers to the cloud computing technology in the HE institution. 4% of the respondents think incident response mechanism and 3% respondents stated portability standards can address the adoption barrier to the cloud computing technology in the HE institution.

Sample Selected Population No	Number of Applied Questionnaires	Quality of Services and Standards	CIAA Triad	Third Party Audit	Legal Issues	Governance and Compliance	Incident Response	Portability Standards
100	100	30	23	17	13	10	4	3
		30%	23%	17%	13%	10%	4%	3%



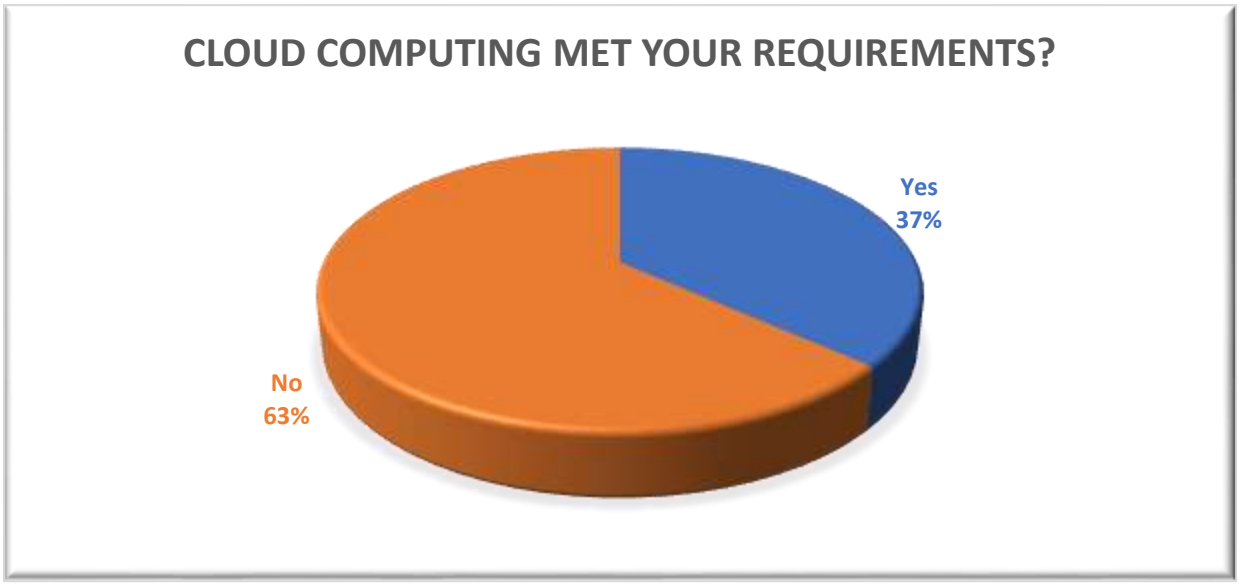
Graph 7 Resolution to adoption barrier to cloud computing

Q8: Did Cloud Computing implementation in HE institution met your inspirations and requirements?

In the response to the above question that was asked from a group of 100 students all respondents were able to answer the question. Majority of respondent that was nearly 63% agreed that the cloud computing technology implementation in the HE institution was not able to meet the inspirations and requirements of the normal users whereas around 37%

agreed that cloud computing technology implementation in the HE institution was able to meet the inspirations and requirements of normal users.

Sample Selected Population No	Number of Applied Questionnaires	YES	NO
100	100	37	63
		37%	63%



Graph 8 Cloud computing meeting requirements

The response gathered from the questions clearly states that the students are worried about the CIAA triad and variable quality of service services from the cloud provider. That is the reason the technology is not meeting their desire goals and inspiration.

7.3.5 Results from the Questionnaire (Staff, Management and Technical Support Team)

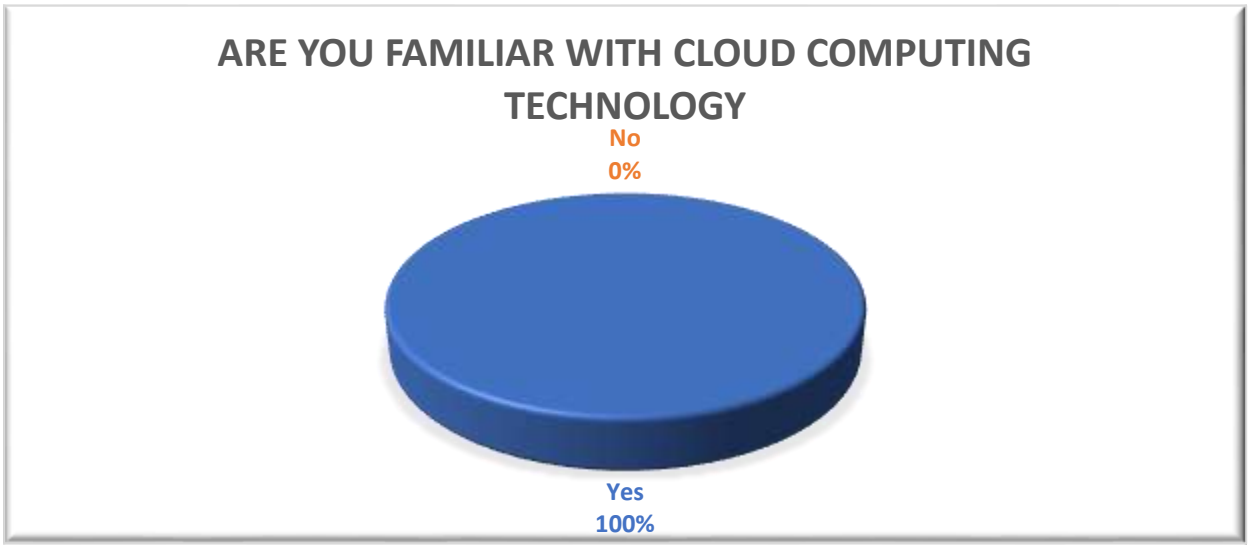
From the initial investigation from the staff, management and the technical support team at HE institutions the following preliminary data were obtained, whose answers are presented one by one question in the tabular format and followed by the graphic representation so that it is easy for readers to understand the data collection. The questionnaire also have multiple

choices that were allowed so that respondents can fill more than one answer for each question. These questionnaire were validated and the respondents were easily able to answer each questions.

Q1: Are you familiar with the cloud computing technology?

In the response to the first questions that was asked from a group of 45 staff there was an overwhelming response to the questions. The questionnaire was given out to a group of selected 45 staff members including the faculty, management, and technical support team who were working in the HE institutions. All respondents replied to the question where 100% confirmed that they are familiar with the "term" of cloud computing technology and the services.

Sample Selected Population No	Number of Applied Questionnaires	YES	NO
45	**45**	**45**	**0**
		100%	**0%**

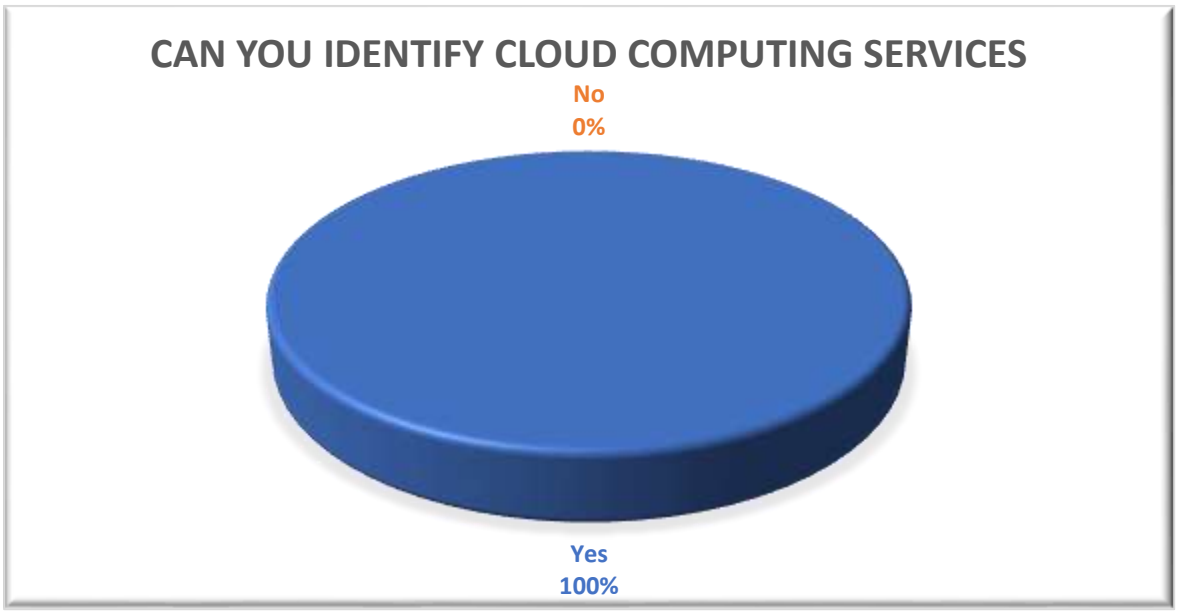


Graph 9 Familiar with cloud computing technology

Q2: Can you identify a cloud computing service?

In the response to the second questions that was asked from a group of 45 staff there was an overwhelming response to the questions. All respondents replied to the question where 100% confirmed that they can confirm the cloud computing services and its application.

Sample Selected Population No	Number of Applied Questionnaires	YES	NO
45	45	45	0
		100%	0%



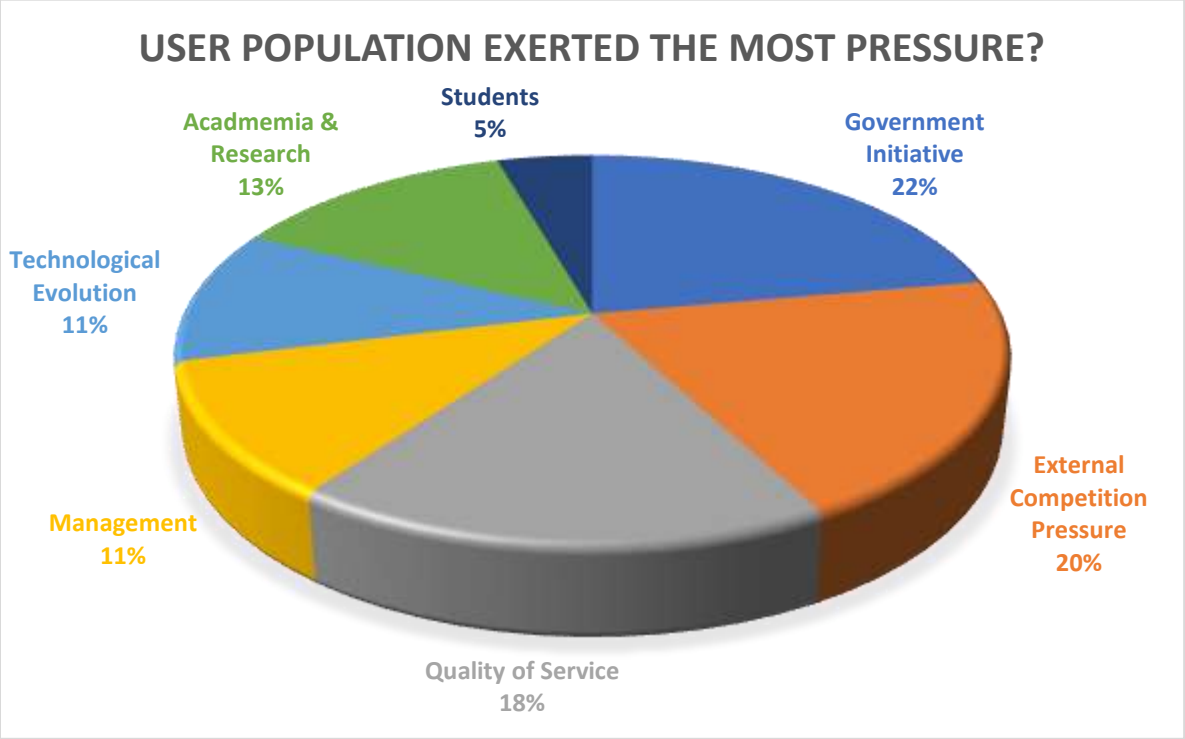
Graph 10 Identify cloud computing services

Q3: Do you know which of the following user populations, within your university, have exerted the most pressure to move towards the cloud?

In the response to the third questions that was asked from a group of 45 staff all were able to respond to the question. 36% of the respondents agreed that due to Government initiative the

cloud computing technology was implemented in the HE institution. According to 22% of respondents external competition and pressure was a result in the adoption of cloud technology in the HE institution. Followed by 16% of respondents agreed that the adoption of cloud technology was because of the senior management whereas 11% of respondents agreed that the implementation of the technology was due to technological evolution process. Academia Research was able to get 11% of respondents' approval followed by 4% respondent agreeing to students' pressure as a reason for the implementation of third party cloud technology in the HE institution.

Sample Selected Population No	Number of Applied Questionnaires	Government Initiative	External Competition Pressure	Quality of Services	Senior Management	Technological Evolution	Academia Research	Students Pressure
45	45	10	9	8	7	5	5	2
		22%	20%	18%	16%	11%	11%	4%

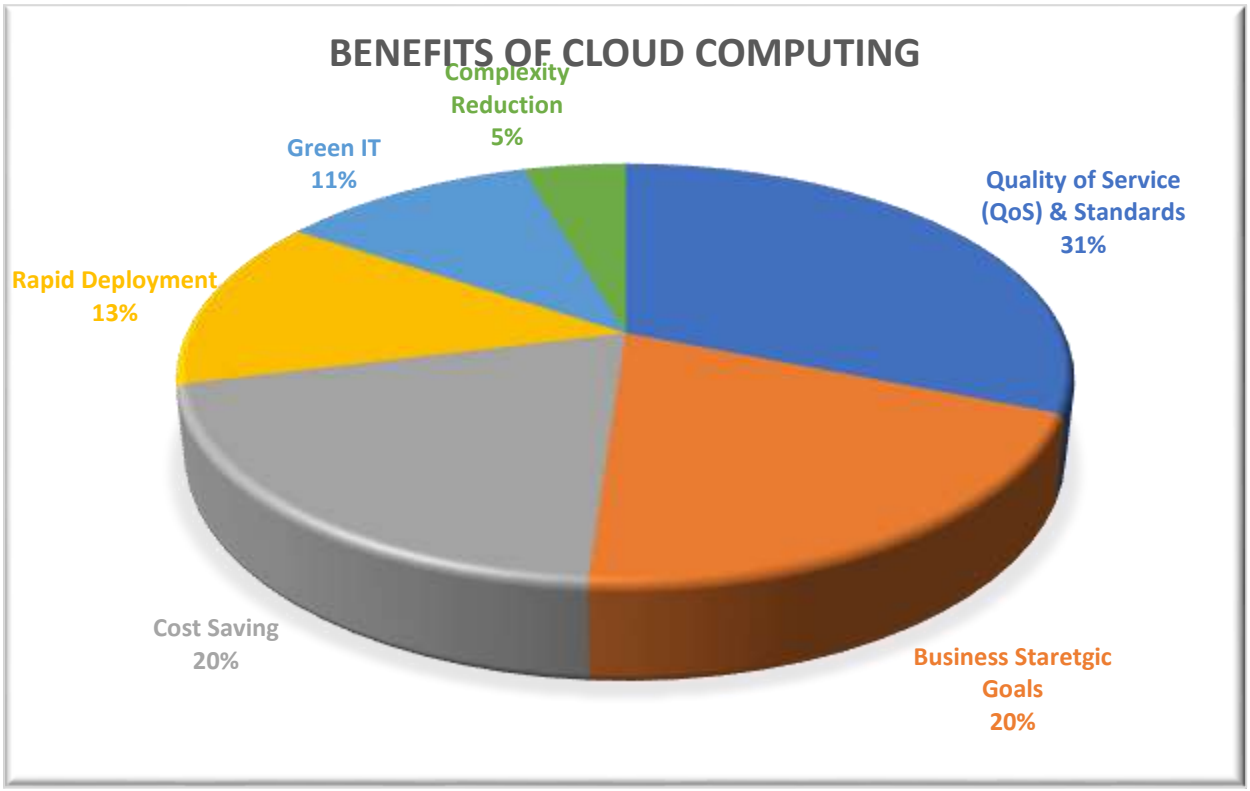


Graph 11 User population exerted pressure to use cloud computing

Q4: What is your perception in-terms of the benefits that can be experienced in the usage of cloud computing technology in the HE institution? Rank any following THREE in the priority by writing 1, 2, 3 in the option.

In the response to the questions that was asked from a group of 45 staff all were able to respond to the question. In order to answer the above question more than 31% of respondents agreed that the main benefit of using the cloud computing technology would be to experience better Quality of Service (QoS) and Standards in the HE institution. 20% of the staff agreed that the usage of cloud computing will help HE institution to achieve business strategic goals whereas 20% of the respondents agreed that the technology will reduce the cost for the HE institution. The next benefit that can be perceived due to the implementation of cloud computing in the HE institution by 13% of the respondents was in the favor of rapid deployment followed by 11% of green IT. According to 4% respondents stated complexity reduction will be benefit due to the implementation of cloud computing in the HE institution.

Sample Selected Population No	Number of Applied Questionnaires	Quality of Service (QoS) Standards	Business Strategic Goals	Cost Saving	Rapid Deployment	Green IT	Complexity Reduction
45	45	14	9	9	6	5	2
		31%	20%	20%	13%	11%	4%

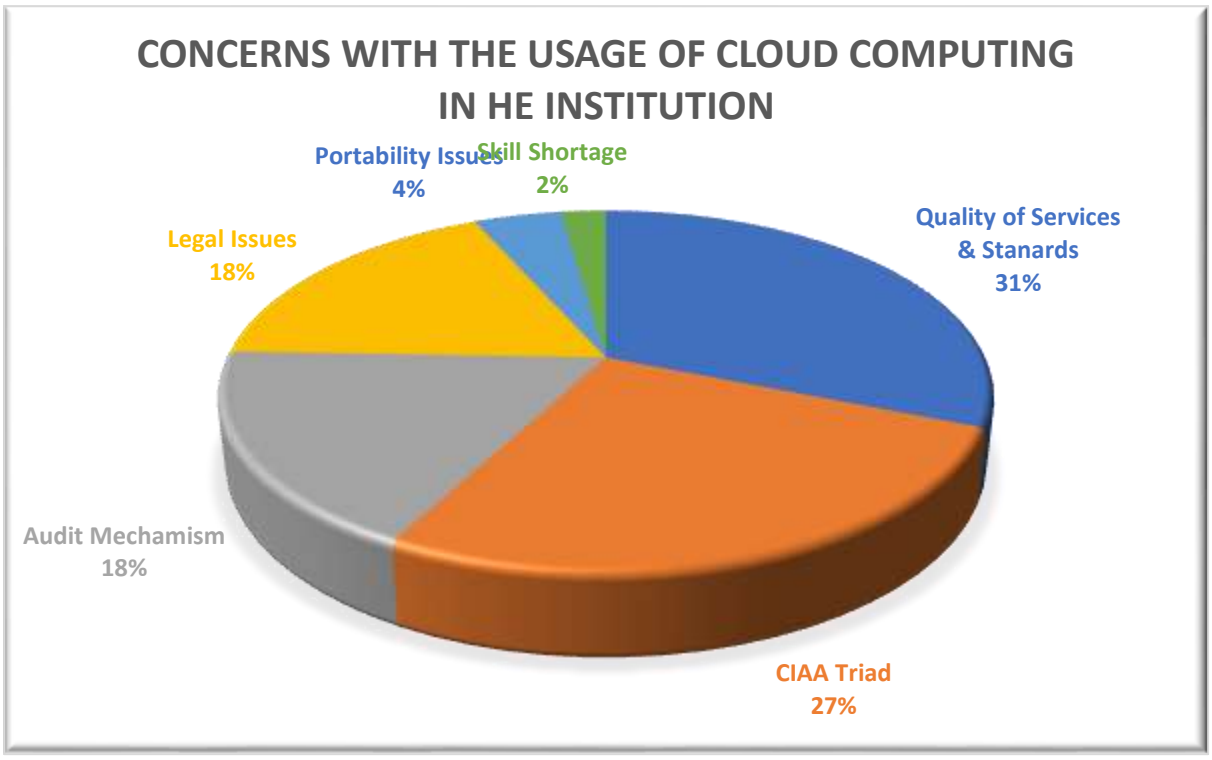


Graph 12 Benefits of using cloud computing technology

Q5: **What you consider as a main concern regarding the use of cloud computing in the HE institution? Rank any following THREE in the priority by writing 1, 2, 3 in the option.**

In the response to the above question that was asked from a group of 45 staff all were able to respond to the question. In order to answer the above question more than 31% of respondents shared their concern regarding variable Quality of Service (QoS) followed by 27% of responded agreeing that lack of standards in CIAA triad is a major concern in the smooth running of cloud computing technology and services in the HE institution. The next two major concern that was highlighted by 18% of respondents was lack of third party audit mechanism and various legal issues that can be a barrier in the use of cloud technology in the HE institution. According to 4% of respondents' portability and interoperability issues followed by 2% of respondent agreed that lack of skills is a main concern for using a cloud computing technology and services in the HE institution.

Sample Selected Population No	Number of Applied Questionnaires	Quality of Services and Standards	CIAA Triad	Audit Mechanism	Legal Issues	Portability and Interoperability	Skill Shortage
45	45	14	12	8	8	2	1
		31%	27%	18%	18%	4%	2%

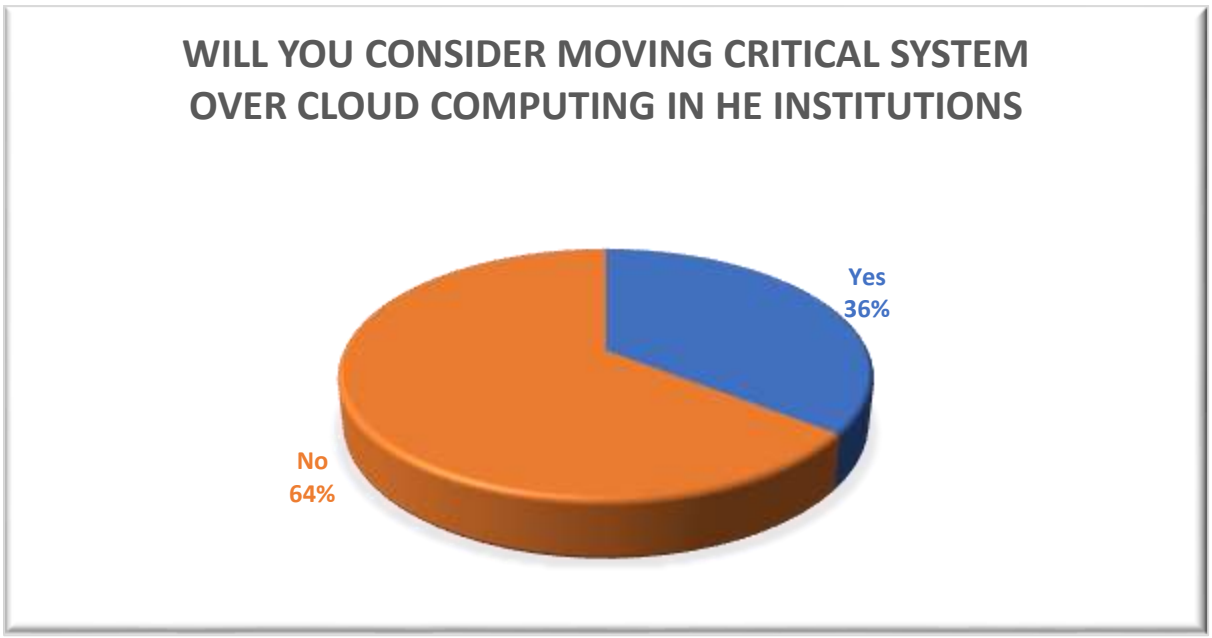


Graph 13 Concern in usage of cloud computing in case study

Q6: **Will you consider moving HE institution critical systems to the cloud computing technology?**

In the response to the above question that was asked from a group of 45 staff all were able to respond to the question. The overwhelming majority 64% of respondents agreed that they will not feel comfortable recommending critical system of HE institution to be moved over the cloud computing technology due the concern shared in the earlier questions whereas 36% respondents feel comfortable moving critical systems to the HE institution. Viewing the response why respondents have stated no, it was clear that there are concerns regarding the variable quality of service standards, concerns related to storage and data security and concerns related to the selection and understanding of the service level agreements.

Sample Selected Population No	Number of Applied Questionnaires	YES	NO
45	45	16	29
		36%	64%

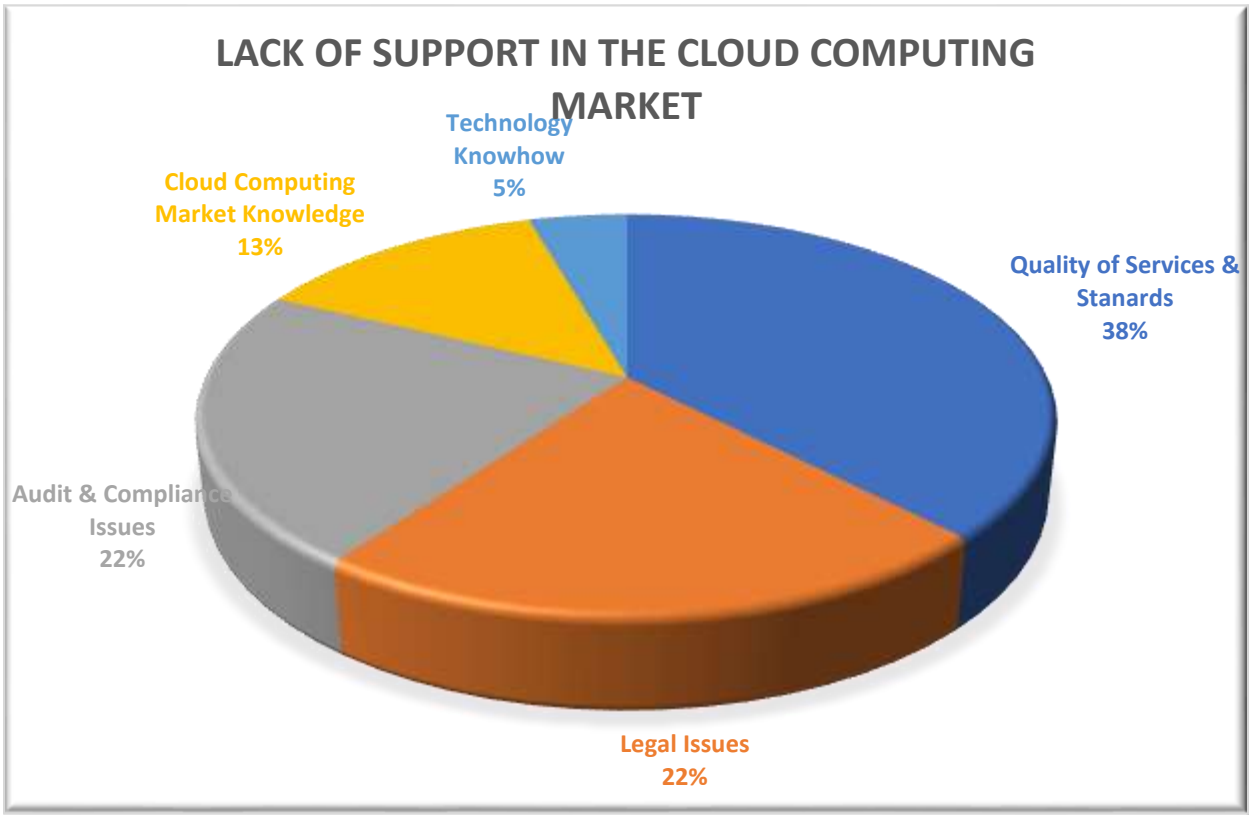


Graph 14 Moving critical system to cloud platform

Q7: In your opinion; which of the following standards there is a lack of support in the Cloud Computing Market?

In the response to the above question that was asked from a group of 45 staff all were able to respond to the question. In order to answer the above question more than 38% of respondents shared their opinion that there is variable or lack of support for Quality of Service (QoS) and standards in the cloud computing market. According to 22% of responded agreed that there is lack of support and guidance on various legal and jurisdiction issues followed by 22% of respondents agreed that there is lack of support or systems for third party audit. According to 13% of respondents agreed there is lack of support and guidance on cloud computing market followed by 4% of technological knowhow there is very poor support and guidance system that are available in the market.

Sample Selected Population No	Number of Applied Question naires	Quality of Services and Standards	Legal Issues	Audit and Compliance Issues	Cloud Computing Market	Technology Knowhow
45	45	17	10	10	6	2
		38%	22%	22%	13%	4%



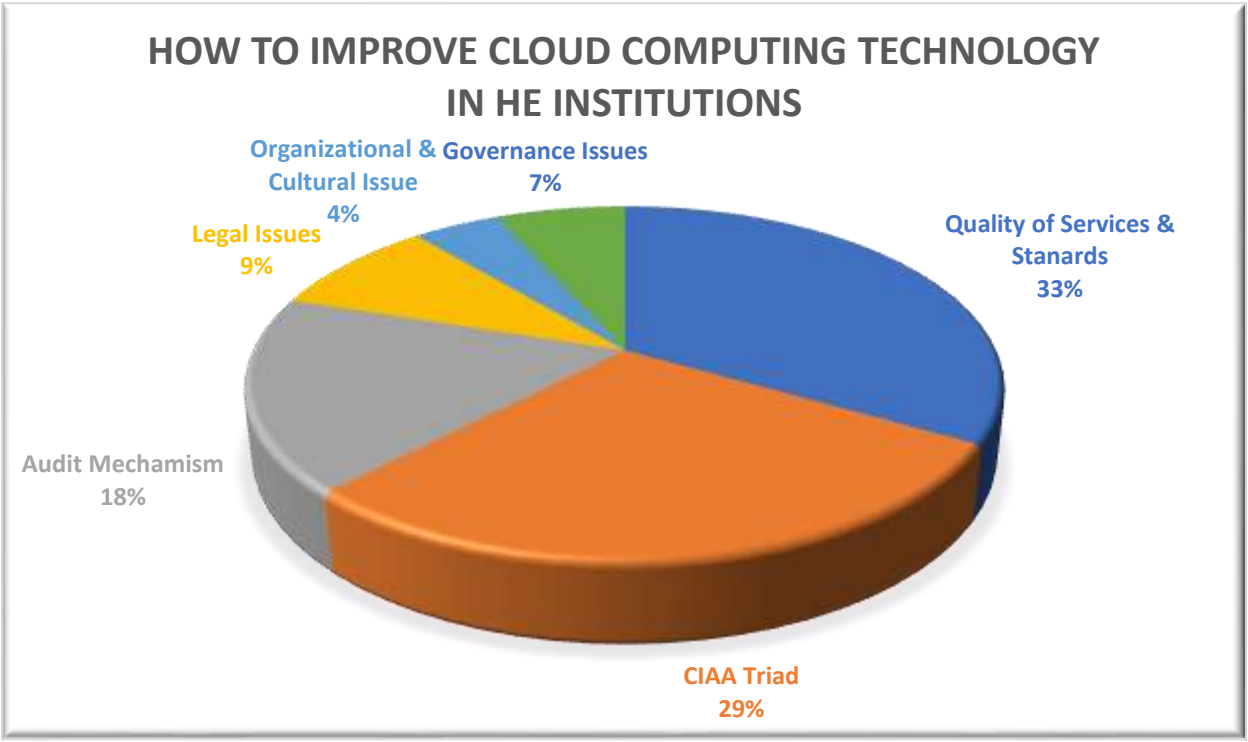
Graph 15 Lack of support in cloud computing market

Q8: **What aspects of cloud computing you think will improve the adoption barrier and ensures smooth adoption of cloud technology in the HE institution? Rank any following THREE in the priority by writing 1, 2 , 3 in the option.**

In the response to the above question that was asked from a group of 45 staff all respondents were able to answer the question. 33% of respondents agreed to improve the usage of cloud computing technology and ensure the smooth adoption of technology in the HE institution; it

is better to have some standards on Quality of Service (QoS) and Standards that is uniformly agreed across the cloud computing market. The next factor that will ensure the smooth adoption and use of cloud computing technology in the HE institution was ensuring and guarantying the CIAA Triad that was agreed by 29% of the respondents followed by 18% of respondent think that third party audit mechanism is required to improve the day-to-day working of the technology in the HE institution. 9% of respondents agreed that clarification and integrating the legal issues whereas 7% of respondents agreed that governance and compliance will ensure the smooth adoption and usage of cloud computing technology in the HE institution. Organizational and cultural issues received 4% of approval from respondents that need to be addressed for smooth adoption and use of cloud technology in the HE institution.

Sample Selected Population No	Number of Applied Questionnaires	Quality of Services and Standards	CIAA Triad	Audit and Compliance Issues	Legal Issues	Governance and compliance	Organizational and Cultural Issue
45	**45**	**15**	**13**	**8**	**4**	**3**	**2**
		33%	**29%**	**18%**	**9%**	**7%**	**4%**

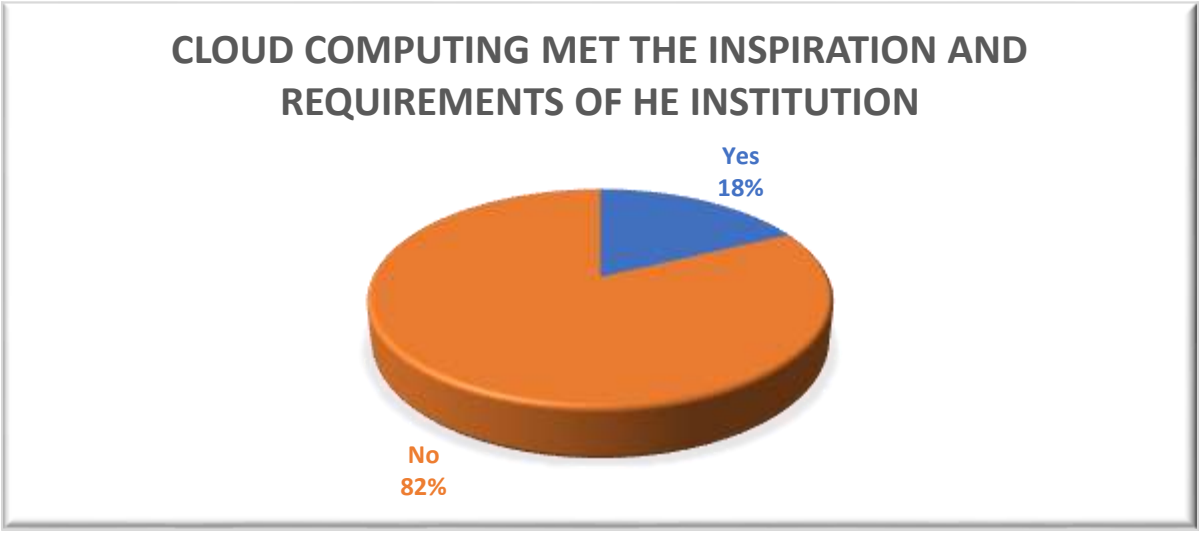


Graph 16 Improve cloud computing in HE case study

Q9: Did Cloud Computing implementation in HE institution met your inspirations and requirements?

In the response to the above question that was asked from a group of 45 staff all respondents were able to answer the question. Majority of respondent that was nearly 82% agreed that the cloud computing technology implementation in the HE institution was not able to meet the inspirations and requirements of the normal users whereas around 18% agreed that cloud computing technology implementation in the HE institution was able to meet the inspirations and requirements of normal users. In the explanation there are concerns regarding the poor quality of service standards offered by the cloud providers, lack of interoperability standards, concerns regarding the CIAA issues and lack of third party audit concerns were the main themes.

Sample Selected Population No	Number of Applied Questionnaires	YES	NO
45	45	8	37
		18%	82%



Graph 17 Cloud Computing Meeting Inspiration & Requirements

7.4 Results Analysis from Interviews (Senior Management, Academic and Technical Support Team)

The detailed interview was conducted with the Management, Academic staff and Technical support team to investigate the issues in the adoption of cloud technology in the HE institutions and formulate a course of action to address any concerns. The qualitative data was obtained, whose answers are presented one by one questions in the Appendix IV. Respondents were 20 who have contributed to complete with their responses. There were 12 Senior Managers, Directors or Head of Departments involved in the strategic decision that are made in the HE institutions. The 8 staff members include the Academic staff and IT Technical support Team. The responded will be represented by a coding system for management team it will be MT, Academic team the code is AT and technical support team it will be TS. The responses gathered will be in the form of qualitative statements that will be written for each question. The interview will last from 30-45 minutes each and notes will be taken throughout the interview. The interview questions allow the respondents to reply in-detail with their opinion. These interview questions were validated and the respondents were easily able to answer each questions.

7.5 Summary

The chapter highlights the major barrier in the adoption and implementation of cloud computing technology and services in the HE institution. It was evident from the responses collected from both the focused groups and the interviews that were conducted, that due to poor absence of a framework or a mechanism there is poor quality of service being offered by the cloud providers. According to the responses collected it was evident that there is no framework that can dictate the quality of service to the providers, evaluate their service, make them accountable according to this framework and ensure the ease of selection of provider. The lack of a framework that is universally agreed by the cloud industry that acts a minimum set of standards is considered as a major barrier in the adoption of cloud computing technology in the specific case study. The respondents have highlighted that due to variable or poor standards of services that is offered by the cloud service provider there are series of adoption challenges such as problems related to CIAA, lack of third party audit standards, no governance and compliance mechanism, cloud users and providers having problems in-terms of understanding and adopting the new legal requirements such as GDPR that will affect the entire cloud industry. The respondents were clear in their response that there is lack of guidance and support from the cloud computing market and issues such as portability, interoperability, variable standards of incident response are major concerns in the existing HE case study. Due to absence of quality of service standards or any framework there is large organizational barrier in the implementation of cloud services and focus group do not feel confident to more their critical systems on the cloud technology at this moment until the issues and challenges are addressed. The responses collected from the focused groups agreed that the perception in-terms of benefits that was promised due to the implementation of cloud computing technology in the HE institution has not met its set standards goals and inspirations. The respondent mentioned barrier such as weak encryption standards, authorization and authentication issues, weak compliance standards, variable incident response standards and no mechanism to verify independently the policies and safeguards of the cloud service provider is a major cause of concern. Issues such as lack of technical skilled labour and minimal support from the cloud industry itself is also a cause of concern that needs to be addressed. Due to absence of a framework that can help the cloud users to easily select the cloud provider, evaluate their services, make them accountable and act as benchmark to set standards is a huge barrier in the adoption and the use of the cloud computing technology. The respondents agreed until the above issues are not addressed the

specific case study will not be able to move their critical systems to the cloud platform and wouldn't be able take full advantage of the technology.

Chapter 8. Discussion of Results

8.1 Introduction

This study is to investigate the problems faced in the adoption and use of cloud computing in the HE institutions. In order to investigate these adoption challenges a detailed investigation was conducted from all stakeholders such as students, staff, management and technical staff. The study was an attempt to investigate these adoption barrier so that these challenges can be addressed and the adoption of cloud computing in the specific case study HE institution can be done smoothly and the case study can take full advantage of the technology. It was evident from the research and the detailed investigation the cloud computing industry has to implement a framework or a universally agreed mechanism that can set standards of service for all the providers to offer better Quality of Service (QoS) to the cloud users. This framework consist of set of standards or criteria that acts as a benchmark for the selection of cloud providers, evaluate their performance, make them accountable and improve the overall level of services across the cloud industry regardless of their hosting location. The framework will ensure that it meets the desired expectations and inspirations of the cloud users and take full advantage of the technology.

Cloud computing is an emerging technology that offers subscription based services, and provide different models such as IaaS, PaaS and SaaS to cater the needs of different users groups. The technology has enormous benefits but there are serious concerns and challenges related to lack of uniform standards or nonexistence of minimum benchmark for level of services across the industry to provide an effective, uniform and reliable service to the cloud users. As the cloud computing is gaining popularity organizations and users are having problems to adopt the service due to lack of minimum service level framework which can act as a benchmark in the selection of the cloud provider and provide quality of services according to the users expectations. The situation becomes more critical due to distributed nature of the service provider which can be offering service from any part of the world. Due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the industry, there are serious concerns raised recently in data security and data privacy breaches, poor authentication and authorization, lack of third party audit and identity management issue, integrity and variable availability standards, confidentiality and

no uniform incident response and monitoring standards. With the implementation of GDPR (General Data Protection Regulation) in the near future there will be serious implications for cloud providers coupled with poor governance and compliance issues are making the situation very complex and affects the adoption and use of cloud computing technology.

This study is an attempt to investigate the problems faced by the HE institutions during adoption and usage of cloud computing due to lack of minimum service level framework and proposes a conceptual model based on uniform minimum model that acts as benchmark for the industry to ensure quality of service to the cloud users. In order to investigate the above problem initially the questionnaires were conducted from students and staff to find their opinion and issues they are facing while using the cloud technology in the HE institution. The data collected from the questionnaires will set key theme areas that will be investigated further using detailed interviews with the management, staff and academic staff. The qualitative approach was used to interview the senior management, academic staff and technical support team to investigate the problems and issues faced while adoption and usage of cloud computing in the HE institution. The purpose of the interview is to collect the management opinion in detail about the issues and concern in the adoption of cloud computing in the HE institutions and what can be done to improve the process. The responded were represented by a coding system for management team it will be MT, Academic team the code is AT and technical support team it will be TS. The responses gathered will be in the form of qualitative statements that will be written for each question. In the following section of the chapter a detailed discussion with analysis will take place explaining the data collected from the investigate stage from all stakeholders. The discussion will be presented in the key theme areas that were highlighted in the investigation stage.

8.2 Familiarity with Cloud Computing Technology

The data collected during the interview process from the senior management shows that the overwhelming majority of the senior management are well aware of cloud computing technology. The responses indicate from the interview shows the senior management, 16 out of 20 have rated their level of awareness or knowledge regarding cloud computing as "confident" that shows that the top executive management is well aware of the technical and business side of the technology. The management feeling so comfortable about the

technology is a positive side as they will need no assistance to make decisions and they will use their experiences and industry knowledge to make strategic decision regarding the use of cloud technology in the HE institution. The same questions was asked from the students and staff in an questionnaire and 100% students and staff respondent by stating that they are familiar with cloud computing technology. The responses collected from students and staff in the questionnaire shows that 93% of students can provide an example of a cloud computing services they have used in the past or they are using currently whereas 100% of staff can provide an example of cloud computing services which they have used. This clearly shows that students, staff and senior management working in the HE institution are well aware of the cloud technology and they are using various cloud services. This indicates that all stakeholders in the HE institution are familiar with the technical aspects of the cloud technology. This finding is very useful as it indicates that everyone involved is using the cloud technology and they feel confident using the technology to support their work or leisure activities.

8.3 Use of Cloud Computing in HE institution in Functional Areas and Experiences

During the investigation, the senior management in the interview were well aware of the functional areas in the HE institution where the cloud computing technology was being used. Whereas the experience of using cloud computing technology in the HE institution was mixed and having serious problems in these functional areas. In their responses to this question in the interview senior management provided examples of various functional areas in the HE institution that were using cloud computing technology such as Email Systems, Help Desk Management, Web Hosting Services, Online Enrolment, Research and Development, Application Development and many other front line services. More than 90 students responded by stating various functional areas in the HE institution where the cloud computing technology is used such as 30% of responded agreed that Email, more than 25.6% responded by stating Research and Development, nearly 18% stated Web hosting in the HE institution is using cloud computing technology. Around 12.2% responded agreed the Library Services and 7.8% stated Application Development is using cloud technology in the HE institution. Nearly 3% of responded were aware that the cloud technology is used to support Help Desk and Calendar services. In order to investigate these functional areas further the interview was conducted to find the experience of using the cloud computing technology in these areas. The experience of using cloud technology in these functional areas have a mixed

review. Some of the experiences of using cloud technology were positive as mentioned by **MT1** "*We are using cloud technology in the Email System and level of service is better than before in-terms of availability.* The positive experience was reinforced by **MT4** "*We have moved our attendance system on cloud technology and it is working fine with very few issues reported so far"*. These responded were happy and satisfied with the use of cloud technology in these functional areas of the HE institution. The opinion collected by the majority of the respondents they were various issues while using the cloud technology in the HE institution. As mentioned by **MT11***: Web Services Hosting and Enrolment online is using the cloud services. We have major issues with massive delay to complete the transactions. The students kept complaining that it was taking too long to complete the enrolment process".* The senior manager highlighted the delay and lack of capacity of the underlying networking to complete the enrolment process quickly as they were facing high number of students to enrol on particular days. The cloud technology was not able to scale quickly to meet the demand and according to the response from the senior management there was a delay in completing the enrolment process by students as there was number of complains made by the existing and potentially new students during the enrolment week. The service availability is the issue which was reported during the peak time according to the respondents. This clearly identifies the variable quality of service offered by the cloud provider where variable service availability standards were reported during the peak time. The respondents also stated that the use of cloud technology to support Research and Development department was providing variable Quality of Service (QoS) standards in-terms of availability issues and concerns from the researchers about the security and privacy of their research. The respondents mentioned as they processes large bulk of data set to support their advanced research, there are variable standards of availability to support research and development activities which is matter of concerns for these respondents. As mentioned by **AT1**: "*The cloud technology is being used to support our Research Departments as we require large processing power to support our research. The quality of services is variable without consistency. It doesnot meet our initial expectation".* As mentioned by **AT2** *"Use of technology to support web hosting was not a good experience as the system was not available and have major problems in terms of availability. Some days there is no issues and everything runs without any problems whereas on other days we have problems".* The response collected clearly shows that due to variable set of standards data and service availability standards offered by the cloud provider are not consistent and cloud users in this case are struggling to host the website. This opinion was reinforced by the technical support team as well. According to **TS2**: "*Use of cloud technology*

to support Research and Development project have a poor quality of service with variable standards of QoS (Quality of Service). These responses clearly shows lack of standards and due to poor availability rate the Research and Development department were not able to use or experience the cloud technology according to their goals and expectation that were initially promised. Now due to lack of availability standards the Research and Development is facing a huge barrier and the experience is not positive at all. The lack of availability standards point of view was reinforced by **AT2**: "*Use of technology to support web hosting was not a good experience as the system was not available and have major problems in-terms of availability:* This clearly shows that the senior management and academic staff both agreed and have experienced that due to poor quality of services the cloud technology was not able bring the desired benefit that was expected by the HE institution.

The experience in the Application Development was also concerning as mentioned by **MT6:** *Application Development is an area for the concern. The quality of service offered by cloud technology is not consistent and I keep getting complains due to poor quality of service availability issues and lack of processing ability. The interoperability is a problem as we have old legacy systems and they cannot operate on the new platform over the cloud.* The technical support team shared the same experiences as mentioned by **TS1:** *The move from traditional in-house model to cloud technology have serious concerns such as data security, privacy, availability as there is lack of guarantee from the service provider.* The concerns regarding data security, data privacy and data confidentiality and availability was raised by various users as they were not comfortable with storing data over the third party server without any stringent policies, framework or a mechanism that is uniform model across the industry and act as a benchmark to all cloud service provider. It was evident from the response given by **MT9***: Some functional areas we had huge barrier to integrate the cloud technology due to legacy system as the new technology doesnot support it. Also there are major concerns regarding the data security, data privacy by various quarters in the HE institution as there is a lack of assurance from the provider.* These major concern related to interoperability and portability were raised with issues such as data security, data privacy as the data will be hosted on the third party servers. As there is lack of guarantee provided by the cloud provider the users at HE institutions are concerned about the security and privacy of their data. These responses collected by various senior management, academic staff, students and technical support team represent a situation where there is poor QoS (Quality of

Services) and standards offered by the cloud provider in various functional areas. Various problems were reported such as lack of availability standards, huge delay to complete the enrolment process, data security, privacy and confidentiality issues and concerns, problems of interoperability and portability as HE institution was having difficulties moving old legacy system over the cloud platform. These problems clearly indicate that there is a lack of framework or set level of standards with fixed guaranteed parameters to ensure that the level of service will meet these expectations of all the cloud users which is major concern for all the stakeholders in the HE institution.

8.4 Main motivation to adopt the Cloud Technology in HE institution.

8.4.1 External and Internal Pressures

During the investigation, the senior management in the interview clearly stated the main motivation, expectation and pressures to move towards cloud computing technology in the HE institution. During the questionnaire from the senior executive management it was evident that there were external pressures on the HE institution to move towards cloud technology. Out of 45 staff that have responded 36% agreed that it was the Government Initiative to move towards cloud technology for the HE institution. As there was drive from the government to move towards cloud technology every HE institutions has to follow the directive. As the government see the future is interlinked with cloud technology and wanted to make the move towards the technology. The response clearly indicate that the HE institution is facing a competition from other competitors that are operating in the higher education sector that was another pressure group that moved the HE institution towards the adoption of cloud computing technology. According to 22% of respondents that was the reason that HE institution moved towards the cloud technology. At the same time nearly 16% of respondents agreed that senior management whereas 11% responded by stated technological and various other departments played a vital role in the adoption of cloud technology in the HE institution. 11% of respondent stated that academia staff and research requirements were the factors in the adoption of cloud technology as it was expected that the cloud computing technology will support the advanced research in the specific case study HE institution. Only 4% respondents stated students were the factor in the adoption of cloud technology in the HE institution. According to the response collected from the respondents it was clear that due to immense pressure from the government and other competitors across the

education sector that have decided to implement the cloud computing technology. Research development was another reason to integrate the technology so that extensive research can be conducted.

8.4.2 Motivation and Expectation from using Cloud Technology in HE institution

The research tried to investigate the motivation and expectation of all the stakeholders from cloud computing implementation in the HE institution. During the interview from the senior management it was clear that there were expecting a lot from the adoption of cloud technology as it will enhance the entire operation and help the institution to meet its strategic objectives. As reinforced by **MT2:** *The main factors what I think should be considered during the adopting of cloud computing technology for HE institution is 1: Guarantee to consistent quality of service being offered by the provider. This is core to the success of adoption of the technology, 2: Ensure that data will be protected from any breach and its integrity and confidentiality is not compromised with better layered security in-place to ensure this. The image of a business is badly damaged if there is breach of data and data security or privacy is compromised. These damages I considered as irreversible to any business and customer will never trust that organization. 3: Incident response from the provider is also crucial and should be considered during the adoption of cloud computing technology."* The response clearly indicate the motivation and expectation of the senior management that the desire to see better quality of services with the adoption of cloud technology where the students, staff and researchers can take full advantage of the latest technologies and enhance their careers further with the use of technology. Also the management expects that with the adoption of cloud technology in the HE institution the data which will be hosted on a third party will be protected and its confidentiality, integrity, availability, authentication, and accountability will be maintained. The respondent also desire to see standards in terms of incident response mechanism which should be uniform across all the cloud service providers. As reinforced by **MT5**. *For a HE institutions it is crucial to have consistency in terms of the services we are providing. Our students demand that level of services should be excellent and consistent. So we should analyze whether the cloud technology can provide better services to our customers (students). If the technology can meet the challenges then it should be adopted in any institution. The second factor that I considered crucial in the adoption of cloud technology of HE institution is reduction of cost for the entire operation. The overall budgets are getting squeezed and value for money is very important. We need a technology that can reduce the overall cost and it the same time*

provides data security and privacy standards. The third factor that should be considered in the adoption of cloud technology is the CIAA triad. The question is whether the technology can provide data security, integrity, availability and privacy standards as there can be provide good services to our students, staff and overall community". The response clearly indicates that the expectation from the senior management is to ensure consistency and improvement in the quality of services offered by the adoption of cloud technology in the HE institution and that is the key requirements which the management wants to achieve so that all the stakeholders are confident in the use the technology. These findings are totally reinforced by the response gathered from the **MT7** that states**:** *My preference is whether the technology will provide a better quality of service and at the same time we can reduce the cost as well. Also the technology can provide sound security, privacy with layers of system to ensure that HE data is kept secure and no unauthorized person can access data. In the next factor that should be considered is the audit and security mechanism of the cloud service provider. Before the adoption of cloud computing technology it is crucial to examine what procedures and safeguards are in-place by the cloud service provider to avoid the inside attack or accidental leakage of data as the resources are being used by many clients. We are also worried about the internal attacks and that can affect the overall quality of service and lead to data breaches".* The expectation and motivation set by the senior management is very high with the use of cloud technology. The technology should provide consistent QoS (Quality of Services) and provide solid guarantees for the data security and data privacy is maintained while the day is hosted on a third party servers. The response desire to see policies and procedures to prevent against the insider attack and require better quality of service across all the cloud service providers.

During the questionnaire, 33% of students and 33% of academic staff responded by stating that better Quality of Service (QoS) is the main expectation and motivation to adopt the cloud technology in the HE institution. The consistent and better QoS (Quality of Services) during the adoption of cloud computing technology in the HE institution is the main expectation and motivation from all the stakeholders as per data gathered during the investigation phase. The next motivation or expectation from the adoption of cloud technology in the HE institution is CIAA Triad (Confidentiality, Integrity, Availability, and Authentication) that should be guaranteed from the cloud provider and reduction in the cost of operation with the use of cloud technology in the HE institution. This areas is a major concern that was raised

during the investigation from all the cloud users in the HE institution. As reinforced by **MT5**. *For a HE institutions it is crucial to have consistency in-terms of the services we are providing. Our students demand that level of services should be excellent and consistent. So we should analyze whether the cloud technology can provide better services to our customers (students). If the technology can meet the challenges then it should be adopted in any institution. The second factor that I considered crucial in the adoption of cloud technology of HE institution is reduction of cost for the entire operation. The overall budgets are getting squeezed and value for money is very important. We need a technology that can reduce the overall cost and it the same time provides data security and privacy standards. The third factor that should be considered in the adoption of cloud technology is the CIAA triad. The question is whether the technology can provide data security, integrity, availability and privacy standards as there can be provide good services to our students, staff and overall community.* The management of the HE institution is expecting solid assurance from the cloud provider that their data will be secured and its privacy will be maintained. The cloud provider should have systems in-place to provide layered security to maintain the CIAA triad and explain those systems should be in-place to improve the cloud adoption rate and improve the confidence of its users. As reinforced by **MT10*:*** *Three main priorities that I considered the most important in the adoption of cloud computing in the HE institutions is offering a reliable, secure technology that can offer better level of services for our students. The technology can help to reduce the cost but at the same time offers better processing speed, network throughput, and availability and help the HE institutions to achieve their objectives.* The response collected identifies three main priorities in the adoption of cloud technology which is secure and reliable platform that provides better service and standards by the cloud providers. The quality of service standards should be uniform regardless of the cloud service provider hosting location. The response is desire to reduce the cost of operation and provide high availability standards so that HE can meets its desire goal and objectives,

The responses gathered from the academic staff agreed on the same principles as mentioned by **AT3**: Three *Main factors that are important according to me is a technology that can reliable and available every day to support our operations. Data is secure and we have guarantee to the quality of services that will be offered so there is no issues later on. Third party audit of the cloud service provider facilities to ensure that provider is following all policies and procedures.* The opinion the academic team reinforced the data collected previously, as they wants assurance that the data that will be hosted on the third party server

will offer data security, privacy and prevents any unauthorized access or modification of data. The priority from the response revolves around the issues of the data security, privacy and data confidentiality which is the core requirement of the cloud users. This was reinforced by technical support team as **TS2** stated, *Data security, data privacy, integrity of data with flexibility to shift from the traditional technology to the cloud technology are the main priorities in the adopting of cloud technology in the HE institution. Data governance strategy is also important as we need guarantee that the data will be stored securely and the service level agreement need to provide strong guarantee.* The motivation and expectation from the senior management, academic staff and technical support team is that the use of cloud technology will ensure CIAA triad and also results in the reduction of cost. This opinion was backed by the data collected from the 20% of students who are expecting assurance in-terms of CIAA Triad 27% think the motivation to move towards cloud is the cost reduction whereas according to the data collected from the questionnaire indicate that 20% of staff indicate that the adoption of cloud technology motivation is related to achieving the strategic goals of the HE institution and the overall cost reduction of the network operation.

The next motivation in terms of cloud adoption technology in the HE institution that was highlighted during the investigation was rapid development, 10% of students responded by stating the cloud technology will be rapidly deployed that will result in saving time. This responses from the technical support team is expecting that the technology will be easily integrated and deployed without any major problems which will save precious time and improve efficiency in the HE institution. This was reinforced by technical support team that they are expecting the technology will enhance the rapid deployment in the HE institution. As mentioned by **TS1:** *We need a technology that provides consistent quality of service that provides high availability rate. The technology is easily deployed in the HE institution and provide us with the flexibility to integrate other technologies with cloud model without any issues in-terms of portability and interoperability. The next factor is the incident response mechanism and response time from the cloud provider should be considered before the adoption of cloud technology.* The response collected was clear that the rapid deployment is a motivation for the technical support team so that they can support the operations in an effective manner. The next major motivation and expectation in terms of adoption of cloud technology in the HE institution was flexibility that was selected by 7% and 3% of students are expecting the flexibility and technological evolution as the major motivation to the

adoption of cloud technology in the HE institution. Whereas staff 11% are expecting that the adoption of technology due to technological evolution, 11% to support academic research, and 16% due to the pressure of the senior management that desire to see the use of cloud technology in the HE institution.

8.4.3 Cloud Technology enabling to achieve Strategic Objectives

The use of cloud technology in the HE institution will provide an enrich learning environment; that will help the organization to meet its strategic objectives. Some of the key strategic objectives that the HE institution desire to achieve is a better quality of services offered to its end-users. The services should provide confidentiality, integrity, availability to the data. The data of the HE institution should be secure and access is done by the authenticated parties only with a very high availability and performance rate. Also the HE institution desires to reduce the cost of operation and provide a technology that can support advanced research. According to the opinion of the overwhelming respondents during the investigation phase the cloud technology will enable HE institution to meet its strategic goals and objectives. As reinforced by **MT2:** *I'm very confident that the adoption of cloud technology in the HE institution will enable us to achieve our strategic goals to provide a better quality of service that provides security, confidentiality to our data. The technology provides us a competitive advantage over our competitors to use more advanced technologies, perform advanced research, services are available to the end-user all the time and performance of the technology will provide a rich learning experiences to our students.* The HE institution set strategic objectives to provider better quality of services in-terms of data security, data privacy, data availability and the technology will provide a supporting environment that meets the challenges of XXI century. This opinion was shared by the academic staff that with the use of cloud technology they are confident that HE institution will support latest research and prepare students well for the real world issues in an effective manner. According to the response from **AT1:** *The cloud computing technology in the HE institution will ensure to provide rich learning environment to our students so they are ready for the real world challenges. At the same time the technology can ensure smooth and effective collaboration between our HE institution and other institutions to support research and development.* The HE strategic objectives is to provide excellent QoS (Quality of Services) that can provide reliable service to their students, support research and development

carried out by their staff. These services offered by the cloud provider should offer guarantee so that advanced research can be conducted in the HE institution and help to achieve its strategic objectives. As mentioned by **AT2:** *Our strategic goals dictate that we need to provide an excellent and reliable service to our students that ensures that students, staff, research data is kept and processed in save, secure and reliable manner. Provides guarantee of services. Researchers can conduct advanced research and enjoy the experience of processing large data sets and services are always available without any disruption. The technology should reduce the cost and allow the flexible transition from the traditional model to the cloud model.* There is the expectation from the technical support team as well that the use of cloud technology will help the HE institution to achieve its strategic goals that were set by the senior executive management. These goals are to provide secured, reliable, authenticated services that can meet the expectation of the users but at the same time the cost of the operation is reduced and technology supports advanced research. This was reinforced by ***TS1:*** *The main strategic goals is to provide a quality of service that ensure the data is stored and processed securely and its privacy is maintained. Also we can reduce the cost, provides flexible transition journey and provide a technology that can allow HE institution to meet the challenges of the XXI century. We are hoping that the cloud technology can help us to meet all these objectives.* The management desires to reduce the cost on the technology as there is reduced budget from the central government. The reduction of the cost is a strategic objective and with the use of cloud technology the respondents are confidents that cost reduction objective will be met. As reinforced by **MT9***: We are facing a massive budget constraints due to changes in the public spending reduction. With the use of cloud technology we will be able to reduce the overall spending in technology that will allow us to meet one of our strategic goals. There are concerns related to data security and privacy in which we still require strong guarantees from the service provider.* The respondents are confident that with the use of cloud technology the HE institution will achieve its desire goals and objectives by providing better QoS (Quality of Service) that exceeds the expectation of all the users.

8.5 Major barriers in the Adoption of Cloud Computing Services

8.5.1 Poor Quality of Service

In order to investigate the barrier to the adoption of cloud computing technology a detailed investigation was conducted from students and staff in the form of questionnaire followed by detailed face to face interviews. The major concern raised by the student was poor Quality of Service (QoS) standards as 33% indicated, that variable level of service as barrier to the adoption and use of cloud technology. Whereas more than 31% of staff respondents shared the same adoption barrier as variable Quality of Service (QoS), is not beneficial for the confidence of cloud users. Due to absence of a framework or a universally agreed mechanism that level of service offered by the providers is not consist and does not matches their service level agreement set standards. The students and staff are experiencing poor level of services offered by the cloud provider which is a major cause of barrier to the adoption of cloud computing technology in the HE institution.

In order to investigate this further face to face interview was conducted. The senior management was able to reinforce the same opinion that due to lack of framework there is poor quality of service offered. This poor quality of service is affecting areas such as data security, privacy, integrity and data availability. As stated by **MT1:** *The major barrier in the adoption and implementation of cloud computing technology in the HE institution was a lack of standards or lack of service level framework that allow the end-users to compare and select the service that is required, also a framework that provides a guarantee to the level of services that will be offered by the cloud provider. We at the HE institution struggle to find any level of framework that provides a guarantee to a level of services that can set standards to the cloud computing industry.* This was reinforced by **MT2:** *Lack of quality of services offered by various providers according to me was major barrier to adoption and implementation of cloud computing technology in the HE institution. The standards of data security, data access, confidentiality, availability, audit mechanism and legal issues is based on variable level of services that depends on each cloud provider.* It was evident from the management point of view that due to absence of a framework or a mechanism there is lack of quality of service which is major barrier in the adoption of cloud computing technology in the HE institution. When the interview was conducted with the academic staff they have mentioned the level of a framework is a major barrier to the adoption of cloud computing

technology in the HE institution. Due to the absence of the framework there is problems in-terms of available of service, poor incident response mechanism, authentication and authorization problems. As stated by the academic team **AT1*:*** *According to me the top of these barrier will be the lack of standards in-terms of availability of services. As I'm involved in the advanced research and our requirements are to process large data sets. We have struggled a lot to have the services always available at a good standards that can support the processing of data.* The third target audience the technical support team agree that it was major challenge to select a cloud provider as there is an absence of a framework that ease the process of cloud service provider selection, evaluate their services and make them accountable. According to technical support team respondent **TS1:** *We struggled to find a provider that can offer a quality of services that they are ready to provide solid guarantee. There was no benchmark or standards where we can compare one provider with another provider to assess and compare the level of services. This delay the entire process a lot.* It was evident from three different target groups that poor quality of service is a major barrier to the adoption of cloud computing technology. Due to the absence of a framework that is agreed by all the cloud service providers there is poor level of service offered in all areas which is a major adoption barrier of cloud computing technology in the HE institution.

8.5.2 CIAA Problems

The next major barrier to the adoption of cloud computing technology is the concern raised by 23% of students was related to CIAA issues such as confidentiality, integrity, availability and authentication mechanism. The response from academic staff 27%, stated that lack of standards in CIAA triad is a major concern in the smooth running of cloud computing technology and services in the HE institution. The data collected from questionnaire and interviews reflect the same. When it was investigated further it was evident from the interview from the senior management, academic staff and technical support team that the concerns related to CIAA are really barriers to the adoption of the cloud technology in the HE institution. According to the management team **MT2:** *The standards of data security, data access, confidentiality, availability, audit mechanism and legal issues is based on variable level of services that depends on each cloud provider. Some providers support detailed layered security with audit mechanism to have an extra layer of check whereas other providers are not robust in their processes.* The same point of view was reinforced by

another member of the management team as stated by **MT6:** *According to me the major barrier in the adoption of cloud technology in the HE institution is issues related to confidentiality of data, Integrity of data, privacy of data, availability of data and accountability to secure the data. The level of services offered is this regard are lacking and are cause of serious concerns.* These concerns are evident that the management feel that CIAA is a major barrier to the adoption of cloud computing technology. The data collected from the academic team also shows the CIAA as a major barrier to the adoption of cloud computing technology. As reinforced by academic team **AT2:** *Three barriers are lack of standards, concerns about data security, data privacy, and poor audit mechanism are creating problem in the adoption of cloud technology in the HE institution.* This shows that academic team is also worried and consider data security, privacy, integrity and authentication as major barrier to the adoption of cloud computing technology. The respondents from the technical team considered CIAA as a major barrier to the adoption of cloud computing technology as stated by **TS1** "*The next barrier was lack of comprehensive systems to ensure security, privacy to data from different providers".* The evidence collected from all concern target audience when triangulated it was clear that student, staff, management and technical support team view CIAA as a major barrier to the adoption of cloud computing technology in the HE institution.

8.5.3 Audit Compliance Mechanism Issues

The next barrier to the adoption of cloud computing in the HE according to students relates to the security and privacy of their data. As the data is stored on a third party server the concern is related to the data security and who as a user we can check that data stored on the cloud provider site is safe and all procedures are followed. The cloud users' cannot go themselves to see the cloud provider site but needs a mechanism to check or audit the site independently. From the questionnaires it was clear that 17 % of students and 18% staff agree that independent or third party audit mechanism is required and considered as barrier to the adoption and use of cloud computing technology in the HE institution. This is the only mechanism which can provide guarantee to the cloud users that their data is safe and secured at the cloud provider site. The existing service level framework that in place does not provide this feature due to the absence of a universally agreed framework which can address this challenge. To investigate this further a detailed interview was conducted with the

management and they raised lack of audit mechanism which is independent in the nature as a barrier to the adoption and use of cloud computing technology. As stated by **MT6:** *The level of services offered is this regard are lacking and are cause of serious concerns. Lack of third party audit, and variable incident response mechanism are also a barrier to the adoption of technology.* This was reinforced by the second interview conducted by the senior management team in which lack of audit is a major cause of concern. As reinforced by ***MT12****: I'm concerned about lack of audit mechanism to ensure that all data is kept securely by the third party cloud provider. In my opinion it is major barrier as we will not able to inspect these cloud remote sites and without a detailed third party independent audit how we can ensure that data is saved, processed securely.*

8.5.4 Legal Issues

The next barrier to the adoption and use of cloud computing in the HE institution according to the data collected from student and staff is the implication of legal issues. According to 17% of students and 18% of staff the legal issues such as data protection are the concern and are barrier to the adoption and use of technology. The legal issues such as where the data is stored, who is responsible for the security of data, who is authorized to access data and who will be liable for the damages if the data is lost or its confidentiality is compromised. The issues are the barrier in the adoption of the cloud computing technology in the HE institution. The response collected during the interview from the technical support team **TS2** confirms that: *Legal issues, lack of standards and poor quality of services are major barriers in the adoption of cloud technology in the HE institution.* The concern related to data security and privacy is the paramount for management at the HE institution as well. According to the senior managers until the legal issues are not addressed and there is a framework which can guarantee the protection from law cloud adoption and use will be major challenge. As stated by **MT6:** *According to me the major barrier in the adoption of cloud technology in the HE institution is issues related to confidentiality of data, Integrity of data, privacy of data, availability of data and accountability to secure the data.* It was also reinforced by the management that there is lack of support and advice that is available to provide guidance in-terms of legal issues in the cloud industry. As stated by ***MT2****: The next barrier was lack of advice and support that is available in the cloud market regarding the legal issues and there is shortage of skills sets that creates a major barrier in the adoption of cloud services. There*

are not enough cloud expert skilled workforce available for smooth transition towards cloud environment.

8.5.5 Portability and Interoperability Issues

The next barrier to the adoption and use of cloud computing technology according to the staff working in the HE institution. According to 4% of staff and 3% of student, the portability and interoperability are the major adoption barrier as HE is facing to move their old legacy systems towards cloud computing platform. During the interview the academic staff mentioned that HE old systems cannot move to the cloud platform due to portability and interoperability issues. This is major problem as the academic staff cannot move their data so they were not able to conduct latest research using the cloud platform. As stated by **AT3:** *Portability of the old legacy system towards the cloud platform is a major barrier for us. We cannot move our old data and systems on the cloud platform which is hinders to the adoption of cloud computing technology.*

8.5.6 Governance and Compliance Issues

The next barrier to the adoption and use of cloud computing technology was lack of comprehensive governance and compliance mechanism which can dictate the cloud service providers all policies in terms of data governance, data life cycle, network security, authentication and authorization standards, etc. According to 10% of students the lack of governance and compliance is barrier to the use of cloud technology in the HE institution. During the interview the management was very clear that until there is a clear governance and compliance framework it will be a major barrier in the use of cloud computing technology. As reinforced by ***MT12****: The next adoption challenge is the lack of governance framework which can provide us with the detail of data governance mechanism and site security procedures. This information is not provided by the cloud service provider and for me as a major concern.* The lack of governance and compliance standards has to be addressed so that cloud providers regardless of their hosting location can provide better quality of service and meets the expectation of the cloud users.

8.5.7 Incident Response Mechanism

Like all technologies it is evident that cloud computing technology will have breakdowns and problems. We need a consistent incident response mechanism which can be followed by all cloud providers across the industry. According to students the major barrier is when there is a fault and there is no resolution from the technical support team for a very longtime. According to 4% of student's incident response mechanism as a barrier to the adoption and use of cloud computing technology. According to **MT1**: *Incident response time is also a concern for us as a cloud users and we as HE institution cannot afford to have delay on this. The level of service is variable and not consistent across the cloud industry.* This concerns was reinforced by the technical support team as they are on the front line dealing with all incidents. As stated by **TS1:** *We need a technology that provides consistent quality of service that provides high availability rate. The technology is easily deployed in the HE institution and provide us with the flexibility to integrate other technologies with cloud model without any issues in-terms of portability and interoperability. The next factor is the incident response mechanism and response time from the cloud provider should be considered before the adoption of cloud technology.* The data collected from the interview was evident that we need a consistent standard in terms of incident response mechanism so that more users have confidence in the cloud technology. At the present stage due to the absence of the consist framework or mechanism there is no standards which is the reasons various cloud providers ate not offering the level of service that is expected by the cloud users. As reinforced by the senior management respondents **MT9:** *Not at all. The recent concerns regarding the data breaches is affected everyone in the HE institution in a negative manner. The level of service offered is not meeting the desired expectation. Issues such as lack of third party audit and poor incident response mechanism are major concerns.* In order to improve the adoption rate we need a universally agreed mechanism that states in the service level agreement the benchmark for the response time to each incident and how quickly each incident will be resolved.

8.5.8 Shortage of Skilled Workforce

There is shortage of skilled workforce who are trained to manage, implement, and troubleshoot cloud computing solution. According to 3% of student respondents there is a shortage of skilled staff who can help them to implement cloud computing technology. The

management also agrees that until that train staff this will be considered as a major barrier to the use of technology. As reinforced by **MT7:** *The most important recommendation is to have set of standards that the entire cloud providers have to follow. We need to improve the training and skills related to cloud computing as there is massive shortage in this area right now. Authentication and authorization issues need to be addressed as we have faced data breaches due to this weakness and issues related to data portability and interoperability need to get more importance.* This was reinforced during the interview with **MT2** *the next barrier was lack of advice and support that is available in the cloud market regarding the legal issues and there is shortage of skills sets that creates a major barrier in the adoption of cloud services. There are not enough cloud expert skilled workforce available for smooth transition towards cloud environment.*

8.5.9 Authorization and Authentication Issues

It was evident from the interview that authorization and authentication are a major barrier in the adoption and use of cloud computing technology in the HE institution. According to MT8 **MT8:** *This worries me a lot and I'm totally against moving the critical systems to cloud technology as we speak… These parameters should dictate availability standards, data security, privacy assurances standards, layered security to protect our data, detailed mechanism on internal processes, detailed support on legal issues, authentication standards, accountability of cloud providers if they don't deliver the service they promise and to oversight to all this can be done by a third party audit mechanism. Until these standards are not in place moving the critical HE systems can be very detrimental to the organization.* The academic staff also agrees that authorization and authentication standards used in the cloud computing are not authentic and leads to major data breaches. As stated by academic staff **AT1:** *We have made some progress but meeting all the strategic goals with the adoption of cloud technology we are not at that point right now. The cost reduction is on track but the quality of services offered doesnot meet our expectation. Still concerns related to data security, privacy, integrity and authentication are not addressed. There is a lack of accountability to measure the performance of the cloud service provider. We would like to have a third party to monitor the cloud provider data centre but there is no mechanism right now that can enable this.* The technical support also admits the in the existing framework authentication and authorization is a concern for remote login. As stated by **TS2:** *Remote*

authentication concerns should be resolved. Data Security, privacy, data availability concerns should be resolved to smooth implementation of cloud technology in the HE institution. The data collected from the different target audience reflect the same concern related to weak authorization and authentication mechanism from all the stakeholders in the HE institution. This issues has to be addressed so that more cloud users become confident to use the technology and service level agreement uses comprehensive standards on authentication and authorization.

8.6 Solution to Adoption Barriers in Cloud Computing

8.6.1 Framework of Quality of Service

In the following section, the investigation was conducted to find solutions to the barriers in the adoption of cloud computing in the HE institution. In-order to find the solution students, staff, senior management and technical support team was interviewed to draw solution to the barriers faced in the adoption and use of cloud technology in the specific case study. According to 30% of students, responses agreed to address the adoption barriers to the cloud computing technology and ensure the smooth implementation of technology in the HE institution; it is better to have some standards or a framework on Quality of Service (QoS) that is uniformly agreed across the cloud computing market. This was confirmed from the response collected from the staff, where 33% of respondents agreed to improve the usage of cloud computing technology and ensure the smooth adoption of technology in the HE institution; it is better to have some standards or a uniform framework that dictates the Quality of Service (QoS) and Standards that is uniformly agreed across the cloud computing industry. This framework will make the cloud service provider accountable and evaluate their services against other cloud provider in the market. The data collected from the interview from the senior management also indicate the same that in-order to resolve these adoption barrier there should be a mechanism in-place that can set standards of quality of service offered. As mentioned by **MT1:** *The problem we faced is the selection of the cloud providers as everyone was offering various level of service or standards and there was no benchmark that we can compare the quality of service with. While adoption the cloud service provider going through the service level agreement there was a lot of technical details that was very confusing and consist of technical and legal terms which we were not able to understand or able to compare the services offered by one provider against another cloud provider in the*

absence of a framework. If the cloud industry has to improve they need a selection framework that set some standards which every provider has to adapt and offer. This will allow easy selection of the cloud provider also guarantee of the quality of service. This was reinforced by another interview conducted by the senior manager that confirms that a framework is required to set standards which can be followed by all cloud service providers. As mentioned by **MT4:** *To improve the cloud adoption there is a critical need of framework that set certain rules that providers have to follow. This is not the case as we speak. It was a difficult task to select the cloud provider without these set parameters or framework. Issues such as third party audit need to be incorporated as we need an assurance from an independent third party that our data is secure and systems that are in place are adequate at the cloud provider site.* For the academic staff as well the framework or a mechanism is required to address the adoption barriers to the cloud computing technology in the HE institution. It is considered as the highest priority from the academic staff as mentioned by **AT1:** *My three recommendations are 1: A framework that guarantee Quality of Service that allows potential cloud users to compare the performance of cloud providers with each other.* The framework will act as a benchmark consisting of various parameters or set standards that can address these challenges. The framework or a mechanism can make all service providers accountable and ease the process of selection of cloud provider.

8.6.2 CIAA Standards

One of the major problems in the adoption of cloud computing in the HE institution was the issues related to CIAA (Confidentiality, Integrity, Availability and Authentication) issues. The cloud users in the specific case study have raised their concerns and this barrier has to be overcome to improve the adoption of cloud computing in the specific case study. According to 23%. The next factor that will ensure the smooth adoption and use of cloud computing technology in the HE institution was ensuring and guarantying the CIAA Triad that was agreed by 23% of students and 29% of staff agreed that to resolve the adoption barrier in the HE case study CIAA issues have to be resolved. During the interview phase all managers, academic staff, and technical staff also agreed that that CIAA need to include into a framework which can set standards to address this adoption barrier. The set standards should be followed by all providers across the cloud computing industry to improve the overall quality of service offered by the cloud service providers. According to the senior manager

MT2*: One of the main recommendation to improve the adoption and implementation of cloud computing technology is to meet the client requirements such as data security, data privacy standards, data should be available to our students all the time, provide technical support quickly, offers layered security and allows an audit mechanism that offer an oversight to the entire process which is independent in nature.* This was reinforced by **MT10:** *We are worried about data security, data privacy, integrity and insider attacks that can happen in the data centres. The cloud industry has to improve and provide better quality of services so that more business can move their operation to the cloud technology.* The data collected from the technical support team also reflect the same challenges related to CIAA need to be addressed so that users in the HE case study feel confident to use the technology and concerns related to data security, privacy and integrity are resolved. As reinforced during the interview the technical support member stated **TS3:** *The level and quality of services offered by the providers doesnot give us a guarantee to the level of service. There is different standards of services offered in-terms of data security, privacy and service availability is a major concern. Until the cloud users feel comfortable storing their confidential data on a third party server the cloud adoption rate will not achieve it real potential.* The data collected from the interview and during the questionnaire reflects that all stakeholders require the resolution to the CIAA issues and comprehensive solution is integrated that all cloud users feel comfortable using the technology.

8.6.3 Third Party Audit Mechanism

As the data is stored on a third party servers there are concerns related to the data security, privacy and its integrity. The cloud users in the specific case HE study are worried about the security of their data and the safeguards that are in-place at the cloud provider's site. There should be a mechanism which can allow independent third party verification so that cloud users feel more confident saving their data on the third party servers. According to 17% of students' responded by recommending that a third party audit mechanism is required to improve the adoption barrier to the cloud technology in the HE institution whereas 18% of staff respondent recommended that third party audit mechanism is required to improve the confidence in the cloud users and assess the safety, security and the policies implemented on the cloud providers site. During the interviews the senior managers also confirmed that they would like to see third party independent audit mechanism that can evaluate the policies and

procedures of the cloud provider's site and rate them accordingly. This audit mechanism will ease the selection of cloud provider and increased the confidence of the cloud users that their data is safe and kept with all protection as promised in the service level agreement. This was reinforced during the interview from the senior manager **MT4:** *To improve the cloud adoption there is a critical need of framework that set certain rules that providers have to follow. This is not the case as we speak. It was a difficult task to select the cloud provider without these set parameters or framework. Issues such as third party audit need to be incorporated as we need an assurance from an independent third party that our data is secure and systems that are in-place are adequate at the cloud provider site.* During the interview from the academic staff as well they agree that to address the barrier in the adoption of cloud computing technology it would be a better to have an independent third party audit mechanism which can address this challenge and ensure to the cloud users that there data will be safe and all safeguards are taken according to the service level agreement and best practices to maintains the safety and security of the data. This was mentioned during the interview by the academic team **AT1:** *My three recommendations are 1: A framework that guarantee Quality of Service that allows potential cloud users to compare the performance of cloud providers with each other. 2: Data Security and Privacy concerns have to be address. 3: Independent Audit to ensure that standards are met.* So to address this adoption barrier all respondents agree that there should be an independent third party audit mechanism to address the concerns and barrier to the adoption of cloud computing technology in the specific HE case study.

8.6.4 Legal Compliance Standards

Data privacy is a major concern for cloud users at HE case study. The situation becomes more concerning with legal implications in-terms of data protection act and in the near future the implementation of General Data Protection Regulation. With these new laws there will be serious implications for cloud users, cloud service providers and other organizations that are using third party servers to host data. According to 13% of students and 9% of staff responded by stating that legal and poor compliance is a major barrier and concerns to the cloud users in the HE case study and need to be addressed and integrated in the proposed new solutions so that cloud users feel confidents that their data is safe and organization do not worry about any legal implication in the case of data leakage. Also cloud service providers

regardless of their hosting location have to integrate the legal compliance standards in their service level agreement to ensure all legal standards are followed by the cloud service providers. According to the interview from the senior managers **MT8:** *We need to address this issue so that there is smooth transition towards cloud computing technology. We need assistance in the legal issues as there is minimal support advice from the cloud industry. This is another major concern for us as we are not sure about this area.* This was confirmed by **MT10**: *We need to address legal and compliance issues, audit mechanism issues so that the overall confidence in the use of technology can increase.* The academic team also agreed that legal and compliance issues are a major concern and until the cloud service providers don't follow and integrate these into their system cloud users will be concerned related to data security and privacy. As mentioned by **AT2**: *To improve the adoption of cloud technology it will be better to improve the understanding about the legal issues and its jurisdiction. Data life cycle, data storage, data removal should be explained and ease to change the cloud provider without any lock-in option should be a part of the service level agreement provided by cloud provider.* The cloud service providers need to adapt and integrate the legal compliance into the service level agreement and ensure that all safeguards are in place for data security and privacy. After this it will remove the barrier in the adoption of cloud computing technology in the specific HE case study.

8.6.5 Governance and Compliance Standards

According to 10% of students and 7% of staff, the governance and compliance standards are required to remove the barrier in the adoption and use of cloud computing in the HE case study. The standards should dictate the identity authentication policy, vendor management, network operation, site operation, end-point security and produce reports on various key performance indicators. The governance and compliance standards will ensure that all providers follows the same standards so that the quality of service across the industry is improved. As stated during the interview from the senior manager that governance framework will remove the adoption barrier to the cloud computing technology and increase the confidence of the users to use the technology in HE case study. As stated by ***MT11:*** *My suggestion would be to have set of standards that can allow to compare the services offered by one cloud provider against another cloud provider. A comprehensive governance framework is required which ensure network, data, site security for the cloud infrastructure.*

8.6.6 Portability and Interoperability Standards

The data collected from the students and staff was evident that are serious issues in terms of moving the old legacy systems to the new cloud platform. According to the 4% of students and academic staff they are having serious problems in the portability of the old legacy system to the cloud platform and latest research cannot be conducted due to this. As stated by academic team **AT1***: If you don't mind I would like to add one more key theme to this which is the issues of portability and interoperability to be addressed which is major problem in our case as we are struggling to move our legacy systems to the new platform.* There should be universally agreed standards across the cloud industry to ensure portability and interoperability standards so that old legacy systems can easily be moved to the new cloud platform.

8.6.7 Organizational Issues and Shortage of Skilled Labour

There are other issues such as organizational and cultural changes and shortage of skilled labour workforce need to be addressed so that the adoption barriers can be addressed. According to the 2 % of student responded there is a labour shortage whereas 2% of staff thinks we need to change the culture of the organizations so that cloud technology can be used without any barriers. According to the technical support team there is shortage in the skilled labour workforce. We need to train more staff in the area of cloud computing design, implementation and troubleshooting and address the organizational and cultural issues, so that this barrier in the adoption of the technology can be addressed. During the interview the technical support team stated that **TS3:** *At the same time staff training and organizational barrier to the new technology has to be addressed so that the staff embraces the new technology rather than make hurdles in its implementation. One more issue is the lack of support from the cloud industry and very few skilled labour work force is available, this is a cause of concern that needs to be addressed.* The resolution of this barrier can improve the adoption of the technology in the HE case study which was also reinforced by the management in the interview process as stated by **MT2:** *The next barrier was lack of advice and support that is available in the cloud market regarding the legal issues and there is shortage of skills sets that creates a major barrier in the adoption of cloud services. There*

are not enough cloud expert skilled workforce available for smooth transition towards cloud environment.

8.7 Cloud Computing Model Meetings Requirements

At the end of the investigation the researcher would like to find out whether the existing cloud computing model is meeting the requirements and inspirations of the students, staff, the management, and technical support team in the specific HE case study. To see whether the cloud computing is meeting the desired inspirations and requirements the researcher would like to find out whether the HE stakeholders will be comfortable to move their critical systems such as students database records to the cloud platform or not. The question was asked from the students and according to the response from students 64% stated No and 36% states Yes to moving the critical system to cloud platform. The students are concerns related to moving the critical data to the cloud platform which is due to multiple factors as discussed earlier. The staff don't feel comfortable as well and according to the response received 82% of staff stated they the existing cloud platform is not meeting their desire expectations and inspirations. The weakness in the existing cloud model is not meeting the expectation of the specific case study stakeholders and require a comprehensive overhaul in the cloud framework to meet the expectation and requirements of the cloud end-users. This is not possible until the serious adoption barriers and challenges to the implementation of cloud computing are not addressed.

8.8 Minimum Service Level Framework: Solution to the Adoption barriers in HE Case Study

The following section recommends solutions to the adoption barriers in the HE case study. These recommendation are proposed in the MSL Framework which are as follows:

Availability Standards

- To address the availability barrier in the specific HE case study, the proposed MSL framework set key performance indicators for level of uptime, % of Successful request processed and % of Timely Service provision request. The MSL framework recommends the uptime to be 99.999% and percentage of successful request processed to be also 99.95% using RAID10.

Encryption and Security Standards

- To address the concerns related to CIAA raised by the participants in the specific HE case study, the proposed MSL (Minimum Service Level) framework recommends to implement ENCRYPT II or FIPS security as a minimum standards. To ensure data security and enhanced encryption standards which is mandatory to implement Cryptographic Hardware Module and produce, store and manage key themselves rather than relay on the third party provider. The proposed MSL framework should use content aware encryption to protect against Data Leak Prevention and understand data types.
- The proposed MSL framework recommend on the provider side a lack of Segregation of Duties (SOD), around access around access to key servers and servers having encrypted data should be a cause for concern, as well as DBA's having access to individual keys for databases, or the architecture of the database service reliant on a single key. Controls around protecting the keys themselves, by using **KEK** (Key Encrypting Keys) and generation of encryption keys in-memory, and only storing the encrypted key of key servers are all valid architectural solutions that should be considered in the proposed model.

- Use standard algorithms, minimum AES (Advanced Encryption Standards 256) to be used in the proposed framework. In the proposed framework it is recommended not to use or invent proprietary scrambling techniques or encryption algorithm as they are unproven and easily broken.

- Avoid old insecure encryption standards such as Data Encryption Standard (**DES**).

- Use object security in the proposed MSL framework. Implement basic object security (SQL grant and revoke statements) to prevent access to even the encrypted data.

- In the proposed MSL framework it is recommended do not encrypt primary keys or indexed columns. If you encrypt a primary key, you will have to encrypt all referencing foreign keys. If you encrypt an indexed column, you may end up with slow queries when trying to use the encrypted value.

- The proposed MSL framework recommends to maintain best practices and pass audits the organization should manage their keys in the custody of their own enterprise or that of a credible service from a cryptographic service provider.

- Keys used in existing encryption technology such as DRM and disk encryption products should be managed by central, internal to the enterprise, key storage technology. Hardware Security Modules (HSM) should be used to store keys as well as process cryptographic operations such as encryption/decryption, signing and verifying.

- The proposed MSL framework recommends that enterprise users should go through a registration process to enable cryptographic operations and other processes in the enterprise, such as Content Aware or Format Preserving systems can access encryption/decryption keys as needed.

- Deploy technology integrated into corporate systems based on the identity of all components in the processing chain to make entitlement decisions.

- Manage keys used by the cryptographic processes using binding cryptographic operations.

Authentication Standards

- In the proposed MSL framework, ISO/ IEC 29115, Entity Authentication Assurance Framework is recommended, Four Levels of entity authentication assurance is required to be integrated to address the authentication adoption challenges faced by the cloud users.
- For authentication Authentication Schemes based on Cross Certification for Digital Certificate based Authentication.
- In order to provide authentication the proposed MSL Framework recommends to use SAML Token should be used as Security Assertions Markup Language tokens are XML representations of claims. SAML tokens carry statements that are sets of claims made by one entity about another entity.
- Multifactor authentication should be integrated in the proposed framework which relies on two or more factors where a factor is "something you have" such as a smartcard, "something you know" such as a password or pin, and "something you are" such as a physical fingerprint.
- OTP (One Time Password) used for authentication which is valid for small period of time
- Risk based authorization is used in which the type of authorization uses roles instead of

the user credentials to determine access rights and privileges.

- A flexible and feature-rich extension to SOAP to apply security to web services. The protocol specifies how integrity and confidentiality can be enforced on messages and allows the communication of various token formats such as SAML, Kerberos and X.509.
- Password Management Policy and network authentication mechanism will be integrated in the proposed framework.

Authorization Standards

- In the proposed MSL Framework, role based authorization system is proposed for a cloud environment which is a component of the central security system. XACML is the main standard adopted for this authorization system.
- To ensure authorization standards, role based access control mechanism and provides authorization services to application service providers within a security domain.
- In the proposed MSL framework Policy Administration Point (PAP) component is in charge of providing policy administration services to security administrators. It is the main repository for policies and authorization service provider makes authorization decisions based on security policies created and stored in that repository by security administrators.
- To address the authorization challenges the designed security system PAP component is deployed in the PDP server. PAP provides role defining and assigning services to authorized security administrators.
- In order to assign a role to an end-user, the latter should have a valid registration entry in IDMS. PAP and IDMS are coordinated together and they share a repository for storing and retrieving end-user attributes, such as roles.
- At the same time, security administrator defines role based policy: it represents authorization result based on a combination of resource, action and role.
- Thus, the complete decision service is centralized in a single security system. XACML policy language is used for creating policy files. When a user sends a request to access some resource or service, PEP server intercepts user's request and creates an XACML authorization request. Then the request is sent to the PDP service provider. PDP service provider makes an XACML authorization evaluation against already created policies and returns an authorization decision result back to the PEP.

- As in the case of SSO service, authorization service metadata, which contains the WSDL or the WSDL URL, should be published in IDMS. PKI system establishes a trust relationship between PDP, PAP and PEP components

Incident Management and Reporting Standards

- The proposed MSL framework contains key performance indicators to manage the incidents and report them in a timely manner. Key performance indicators such as % of timely incident reports to customer, % of timely incident response and % of timely incident resolution.
- The classification of incident in the proposed MSL framework with Priority P1 (Critical), P2 (High Priority), P3 (Medium), P4 (Low priority), P5 (Normal).

Interoperability and Portability Standards

- In the proposed MSL Framework, cloud resources such as hardware should be virtualized and physical security control established to remove any concern
- All network devices are virtualized to be shared easily
- Use the open standard for virtualization such as VMware
- Open APIs should be used to facilitate migration of data
- Set procedures for data storage should be adapted in which store unstructured data in a portable format, encrypt data while it is stored or on transit, and ensure to use computable database
- Provide security of the data using SAML or WS-Security for authentication, encrypt data before sending to cloud, log files are encrypted and key secure storage and access policy.
- No Lock in is required, users can move data from one providers to another whenever they want

Identity Management Standards

- Identity Management standards which is a unique reference number used as an identifier in computer software (for example GUID, 32-character hexadecimal string), used for Microsoft's implementation of the Universal unique identifier standard. This is required for Identity Management standards used in the proposed MSL framework.
- The proposed MSL framework to ensure Identity Management standards uses Federated IDM, which provides a directory services that secures user access to

network resources with the ability to setup a trust relationship between various security domains to enable the passing of authentication, authorization and privacy assertions.

Privilege Usage Management Standards

- In the proposed MSL Framework storing the key stroke and session logging mechanism for capturing a detailed record of interactions with an entity (either at the level of individual keystrokes or interactions with the entity).
- The proposed mechanism uses the password vaulting solution, by introducing a software based solution to securely store and manage multiple passwords.
- The proposed MSL framework recommends to use Hypervisor Compliance and Governance standard which gives the capability of privilege management and monitoring by role. The user associated to hypervisor administrators, this also includes management of virtual network, servers, and applications on a cloud environment.

Infrastructure Protection Services Standards

- In the proposed MSL framework to secure the infrastructure the server should use the behaviour malware prevention strategy that provides the ability to identify behaviour of malware based on events.
- The end points used in the cloud provider should have the following features such as anti-virus, host firewall, deployment HIPS/HIDS, whitelisting the devices, media lockdown and use of hardware based trusted asset.

Develop Governance Management and Compliance Process

- The framework ensure the compliance with all specified internal information security policies, control standards and defines a detailed policy management with primary objectives of the security program.
- This policy management defines the standards to maintain an organization structure and process that supports the creation, implementation, exception handling and management of policy that represent business requirements.
- The proposed MSL framework details the policy related to the vendor management, audit management, provide technical training and awareness and compliance standards

Data Management Service Level Standards

The proposed MSL framework provides data classification standards for cloud service customer data, the classification of cloud service provider's data and derived data should be classified.

Data Mirroring, Backup and Restore

- The proposed MSL framework introduces data mirroring, backup and restore strategy as detailed in the following table to enhance data backup and restoration services in the proposed framework. As suggested in the proposed framework data mirroring will be used with 15 minutes RPO (Return Point Objective) and Return Time Objective (RTO).
- The proposed framework defines the data backup method with the use of Full Time and Incremental backup deploying RAID10.
- The proposed MSL framework also introduces the use of backup generators, 30 minutes to restore the cloud users' data and data should be successful restored by 99.95% with the backup strategy deployed

Data Protection

- In order to protect the data, the proposed MSL framework proposes the following features to be adopted by the cloud provider. The meta data should be controlled by defining the metadata accompany the underlying data (e.g., the record of changes to a document maintained as metadata by a word processing application should not be released with the document).
- The proposed MSL framework recommends the use of data masking by obscuring (masking) specific data elements within data stores. It ensures that sensitive data is replaced with realistic but not real data. Also introduces data tagging in which metadata is tagged to a piece of information. It helps describe an item and facilitates it being found again by browsing or searching.
- The proposed MSL framework also recommends the use of electronic signature is a means of indicating that a person adopts the contents of a digital data or that the person who claims to have written a message is the one who wrote it.

Third Party Audit Mechanism

- The proposed MSL framework introduces the third party independent mechanism which can verify the security, procedures in-place in the cloud provider's site. The proposed framework ensures that the third party can physically audit the cloud' providers site and identify and rate the cloud' providers site. Based on the audit report then users can select, evaluate the cloud providers services.

8.9 Summary

The chapter provides a detailed discussion about the data collected during the investigation phase from all the stakeholders in the specific HE case study. All stakeholders during the investigation identified various adoption barrier to the use of cloud computing technology in the HE institution. The barriers are due to the absence of the framework that can set standards and act as a benchmark to all the cloud service providers. It was evident that due to lack of minimum service level framework that will act as a benchmark to provide a uniform service across the industry there are serious concerns raised recently in-terms of security and data privacy breaches, authentication and authorization issues, lack of third party audit and identity management problems, integrity, confidentiality and variable data availability standards, no uniform incident response and monitoring standards, interoperability and lack of portability standards, identity management issues, lack of infrastructure protection services standards and weak governance and compliance standards are major cause of concerns for cloud users in the specific HE case study. Due to absence of universal agreed SLAs for a service model, different quality of services is being provided across the cloud industry. Currently there is no uniform performance model agreed by all stakeholders; which can provide performance criteria to measure, evaluate, and benchmark the level of services offered by various cloud providers in the industry. With the implementation of General Data Protection Regulation (GDPR) in the near future and demand from cloud users to have Green SLAs that provides better resource allocations mechanism, there will be serious implications for the cloud providers and its consumers due to lack of uniformity in SLAs and variable standards of service offered by various cloud providers.

CHAPTER 9. Conclusion and Recommendation

9.1 Overview

Cloud computing has revolutionized the IT industry, offering scalable computing resources. Due to cloud computing technology there is a minimization of in-house IT infrastructure resulted in cost saving, reduced administrative hurdles and provided an attractive outsourcing option. Cloud Computing provides parallel computing and emerged as an efficient technology to meet the challenges of rapid growth of data. The theme of cloud computing is not new as it comprises off technologies such as centralized, distributed, utility computing and incorporate the concept of virtualization. The cloud users do not have to own massive computing infrastructure and no upfront investment is required. The model allows various cloud users to share the network infrastructure provided by cloud provider and pay only for the service being used. This pay-per-use model enables convenient and on demand network access to a shared pool of configurable computing resources such as servers, storage, applications, and services. Cloud computing is a relatively new phenomenon and its implementation in various sectors is have far reaching impacts. The requirements to have dynamic education environment in higher education institutions across the world requires to adopt state-of-the-art practices to reduce infrastructural cost, improve operational efficiency, availability and provide on demand resource allocation. Due to absence of universal agreed framework, different quality of services is being provided across the cloud industry. Currently there is no uniform performance model agreed by all stakeholders; which can provide performance criteria to measure, evaluate, and benchmark the level of services offered by various cloud providers in the industry. With the implementation of General Data Protection Regulation (GDPR) and demand from cloud users to have Green SLAs that provides better resource allocations mechanism, there will be serious implications for the cloud providers and its consumers due to lack of uniformity in SLAs and variable standards of service offered by various cloud providers.

The proposed Minimum Service Level (MSL) framework, provides a set of minimum and uniform standards in the key concern areas raised by the participants of HE institution which are essential to the cloud users and provide a minimum quality benchmark that becomes a uniform standard across the industry. The proposed MSL framework is an attempt to reduce

the adoption barrier of the cloud technology and set minimum uniform standards followed by all the cloud providers regardless of their hosting location so that their performance can be measured, evaluated and compared across the industry to improve the overall QoS (Quality of Service) received by the cloud users, remove the adoption barriers and concerns of the cloud users in the HE institution and increase the competition across the cloud industry. The following section will explain different standards used by the proposed MSL framework to address the adoption barrier in the HE case study.

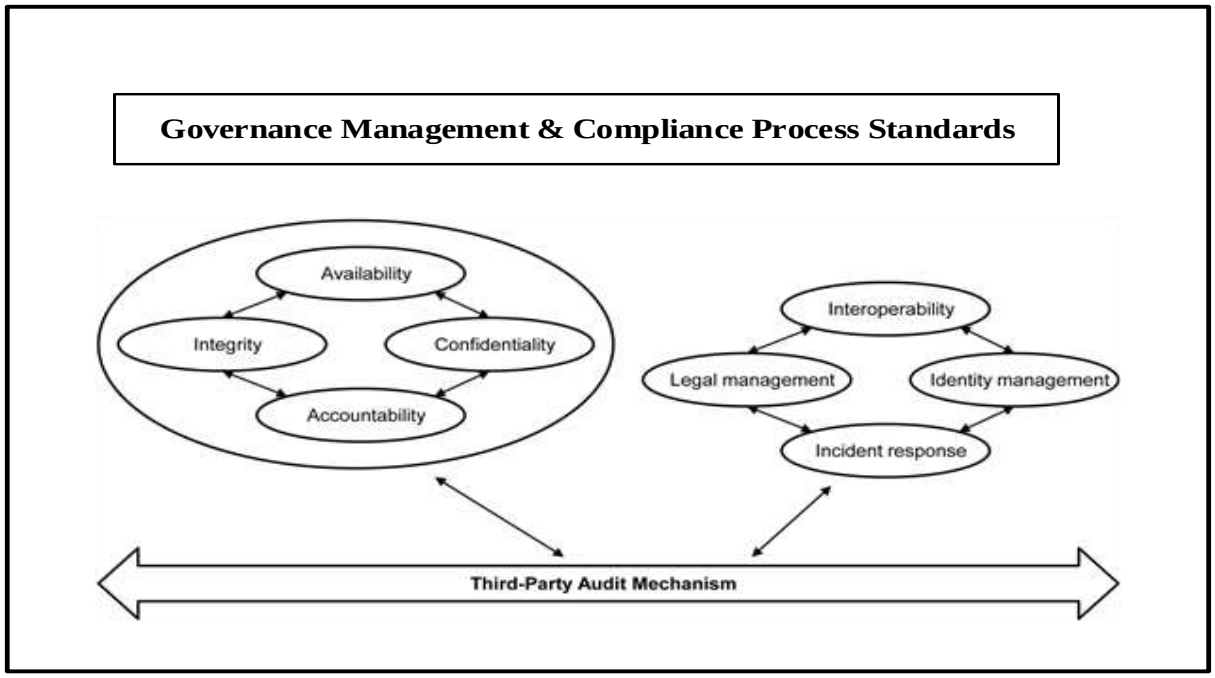


Figure 9.1 Minimum Service Level Framework

9.2 Research Contribution Minimum Service Level Framework: Solution to the Adoption barriers in HE Case Study

To resolve the adoption barriers of the cloud computing in the HE case study could be with the implementation of MSL (Minimum Service Level) Framework. The research contribution are as follows:

Availability Standards

- To address the availability barrier in the specific HE case study, the proposed MSL framework set key performance indicators for level of uptime, % of Successful request processed and % of Timely Service provision request. The MSL framework

recommends the uptime to be 99.999% and percentage of successful request processed to be also 99.95% using RAID10.

Encryption & Security Standards

- To address the concerns related to CIAA raised by the participants in the specific HE case study, the proposed MSL (Minimum Service Level) framework recommends to implement ENCRYPT II or FIPS security as a minimum standards. To ensure data security and enhanced encryption standards which is mandatory to implement Cryptographic Hardware Module and produce, store and manage key themselves rather than relay on the third party provider. The proposed MSL framework should use content aware encryption to protect against Data Leak Prevention and understand data types.
- The proposed MSL framework recommend on the provider side a lack of Segregation of Duties (SOD), around access to key servers and servers having encrypted data should be a cause for concern, as well as DBA's having access to individual keys for databases, or the architecture of the database service reliant on a single key. Controls around protecting the keys themselves, by using **KEK** (Key Encrypting Keys) and generation of encryption keys in-memory, and only storing the encrypted key of key servers are all valid architectural solutions that should be considered in the proposed model.

- Use standard algorithms, minimum AES (Advanced Encryption Standards-256) to be used in the proposed framework. In the proposed framework it is recommended not to use or invent proprietary scrambling techniques or encryption algorithm as they are unproven and easily broken.

- Avoid old insecure encryption standards such as Data Encryption Standard (**DES**).

- Use object security in the proposed MSL framework. Implement basic object security (SQL grant and revoke statements) to prevent access to even the encrypted data.

- In the proposed MSL framework it is recommended do not encrypt primary keys or indexed columns. If you encrypt a primary key, you will have to encrypt all referencing foreign keys. If you encrypt an indexed column, you may end up with slow queries when trying to use the encrypted value.

- The proposed MSL framework recommends to maintain best practices and pass audits the organization should manage their keys in the custody of their own enterprise or that of a credible service from a cryptographic service provider.
- Keys used in existing encryption technology such as DRM and disk encryption products should be managed by central, internal to the enterprise, key storage technology. Hardware Security Modules (HSM) should be used to store keys as well as process cryptographic operations such as encryption/decryption, signing and verifying.
- The proposed MSL framework recommends that enterprise users should go through a registration process to enable cryptographic operations and other processes in the enterprise, such as Content Aware or Format Preserving systems can access encryption/decryption keys as needed.
- Deploy technology integrated into corporate systems based on the identity of all components in the processing chain to make entitlement decisions.
- Manage keys used by the cryptographic processes using binding cryptographic operations.

Authentication Standards

- In the proposed MSL framework, ISO/ IEC 29115, Entity Authentication Assurance Framework is recommended, Four Levels of entity authentication assurance is required to be integrated to address the authentication adoption challenges faced by the cloud users.
- For authentication Authentication Schemes based on Cross-Certification for Digital Certificate-based Authentication.
- In order to provide authentication the proposed MSL Framework recommends to use SAML Token should be used as Security Assertions Mark-up Language tokens are XML representations of claims. SAML tokens carry statements that are sets of claims made by one entity about another entity.
- Multifactor authentication should be integrated in the proposed framework which relies on two or more factors where a factor is "something you have" such as a smartcard, "something you know" such as a password or pin, and "something you are" such as a

physical fingerprint.

- OTP (One Time Password) used for authentication which is valid for small period of time
- Risk based authorization is used in which the type of authorization uses roles instead of the user credentials to determine access rights and privileges.
- A flexible and feature-rich extension to SOAP to apply security to web services. The protocol specifies how integrity and confidentiality can be enforced on messages and allows the communication of various token formats such as SAML, Kerberos and X.509.
- Password Management Policy and network authentication mechanism will be integrated in the proposed framework.

Authorization Standards

- In the proposed MSL Framework, role-based authorization system is proposed for a cloud environment which is a component of the central security system. XACML is the main standard adopted for this authorization system.
- To ensure authorization standards, role-based access control mechanism and provides authorization services to application service providers within a security domain.
- In the proposed MSL framework Policy Administration Point (PAP) component is in charge of providing policy administration services to security administrators. It is the main repository for policies and authorization service provider makes authorization decisions based on security policies created and stored in that repository by security administrators.
- To address the authorization challenges the designed security system PAP component is deployed in the PDP server. PAP provides role defining and assigning services to authorized security administrators.
- In order to assign a role to an end-user, the latter should have a valid registration entry in IDMS. PAP and IDMS are coordinated together and they share a repository for storing and retrieving end-user attributes, such as roles.
- At the same time, security administrator defines role-based policy: it represents authorization result based on a combination of resource, action and role.

- Thus, the complete decision service is centralized in a single security system. XACML policy language is used for creating policy files. When a user sends a request to access some resource or service, PEP server intercepts user's request and creates an XACML authorization request. Then the request is sent to the PDP service provider. PDP service provider makes an XACML authorization evaluation against already created policies and returns an authorization decision result back to the PEP.
- As in the case of SSO service, authorization service metadata, which contains the WSDL or the WSDL URL, should be published in IDMS. PKI system establishes a trust relationship between PDP, PAP and PEP components

Incident Management & Reporting Standards

- The proposed MSL framework contains key performance indicators to manage the incidents and report them in a timely manner. Key performance indicators such as % of timely incident reports to customer, % of timely incident response and % of timely incident resolution.
- The classification of incident in the proposed MSL framework with Priority P1 (Critical), P2 (High Priority), P3 (Medium), P4 (Low priority), P5 (Normal).

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- In order to protect the data, the proposed MSL framework proposes the following features to be adopted by the cloud provider. The meta data should be controlled by defining the metadata accompany the underlying data (e.g., the record of changes to a

document maintained as metadata by a word processing application should not be released with the document).

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- The proposed MSL framework also recommends the use of electronic signature as a means of indicating that a person adopts the contents of a digital data or that the person who claims to have written a message is the one who wrote it.

Third Party Audit Mechanism

- The proposed MSL framework introduces the third party independent mechanism which can verify the security, procedures in-place in the cloud provider's site. The proposed framework ensures that the third party can physically audit the cloud providers site and identify and rate the cloud providers site. Based on the audit report then users can select, evaluate the cloud providers services.

9.3 Cloud Computing Implementation Evaluation Criteria

In order to implement a cloud computing solution there is a need for an evaluation criteria in the MSL Framework. The research contributes by compiling an evaluation criteria as seen from Appendix V.

9.3.1 Purpose of the Document

The purpose of the "Cloud Computing Implementation Evaluation Criteria" is as follows:-

- To provide a set of standards for cloud service providers and cloud users as to what security features is a requirements in the implementation of cloud computing in the organization.
- This document will ensure that cloud service providers will integrate security to satisfy the cloud user requirements, maintain CIAA (Confidentiality, Integrity, Availability, Authentication) standards and particular emphasis on maintaining standards across the cloud computing industry.

- To provide potential cloud users with a metric with which to evaluate the degree of trust that can be placed on the cloud service provider and ease of the selection of the cloud service provider.
- To provide a basis for specifying security requirements in acquisition specification.

9.3.2 Requirements: Cloud Computing Implementation

Requirement 1: Confidentiality

Only authorized users to access sensitive and protected data using cloud computing system. The specific mechanism should be in-place to ensure confidentiality and safeguard data from harmful intruders

Requirement 2: Integrity

In the implementation of cloud computing system it should ensure the data integrity is maintained and the assurance of the accuracy and consistency is entrenched in the cloud service provider model. The cloud computing implementation should ensure that data over its entire life-cycle and is a critical aspect of the design, implementation and usage of any system which stores, processes or retrieves data maintains its integrity throughout the life cycle.

Requirement 3: Data Availability

In the implementation of cloud computing system data is available to its users. The cloud computing provider should ensure that data continues to be available at a required level all the time.

Requirement 4: Authentication

In the implementation of cloud computing system data authentication should be major entity to ensure data is authentic and real. The cloud computing service provider should ensure identity federation to identify the authentic users and make informed decisions. The

requirement is to promote efficiency, reduce costs, and enable credential reuse in different scenarios. These standards will ensure cross border and cross-organization services.

Requirement 5: Accountability

In the implementation of cloud computing system accountability should be ensured for the level of service provided by the cloud service provider. The cloud service provider services should be measured against the key performance indicators and if these parameter are not met then it should be held accountable.

Requirement 6: Incident Response Mechanism

Incident response mechanism should be consistent and uniform across the cloud service provider. The requirement is an organized approach to address and manage the aftermath of security breach or any cyberattack.

Requirement 7: Legal Management

In the implementation of cloud computing system it should follow all legal requirements in-terms of GDPR (General Data Protection Regulation).

Requirement 8: Interoperability Standard

In the implementation of cloud computing system the interoperability standards should be maintained so that old legacy system can be transferred over the cloud computing platform.Cloud interoperability means that data can be processed by different services on different cloud systems through common specifications. Cloud portability means that data can be moved from one cloud system to another and that applications can be imported and run on different cloud systems at an acceptable cost.

Requirement 9: Third Party Audit Mechanism

There should be mechanism that ensures a third party audit mechanism to check the standards that are followed by cloud service provider. This audit report should be made public so that cloud service providers should be held accountable for the level of service provided and potential cloud users can assess the quality of service.

Requirement 10: Governance Management

The requirement is to have a comprehensive governance management standards in the implementation of cloud computing system to maintain standards and governance mechanism.

9.3.3 Three Phases

The Cloud Implementation Evaluation Criteria has three phases as seen from Appendix V. Each phase has different level of criteria and credentials to ensure different level of security in the implementation of cloud computing.

1: Minimal Standards: As the name suggest provides minimal protection and meets minimum requirements standards in terms of CIAA standards and other key requirements.

2: Medium Standards: The second phase contains mediocre protection and meets some requirements in terms of CIAA standards and other key requirements..

3: Enhanced Standards: The last phase contains enhanced protection and meets all the requirements in terms of CIAA standards and other key requirements.

9.4 Research Final Remarks

The proposed Minimum Service Level (MSL) framework, provides a set of minimum and uniform standards in the key concern areas raised by the participants of HE institution which are essential to the cloud users and provide a minimum quality benchmark that becomes a uniform standard across the industry. The proposed MSL framework is an attempt to reduce the adoption barrier of the cloud technology and set minimum uniform standards followed by all the cloud providers regardless of their hosting location so that their performance can be

measured, evaluated and compared across the industry to improve the overall QoS (Quality of Service) received by the cloud users, remove the adoption barriers and concerns of the cloud users in the HE institution and increase the competition across the cloud industry. The MSL framework to address the adoption barrier in the HE case study such as in terms of security and data privacy breaches, authentication and authorization issues, lack of third party audit and identity management problems, integrity, confidentiality and variable data availability standards, no uniform incident response and monitoring standards, interoperability and lack of portability standards, identity management issues, lack of infrastructure protection services standards and weak governance and compliance standards are major cause of concerns for cloud users. The proposed MSL framework agreed by all stakeholders; which can provide performance criteria to measure, evaluate, and benchmark the level of services offered by various cloud providers in the industry. With the implementation of General Data Protection Regulation (GDPR) in the near future and demand from cloud users to have Green SLAs that provides better resource allocations mechanism, there will be serious implications for the cloud providers and its consumers due to lack of uniformity in SLAs and variable standards of service offered by various cloud providers.

9.5 Future Work

The MSL (Minimum Service Level) Framework is used in the HE case study can be extended to other areas. The same framework can be tested in other areas apart from the education sector such as banking, health services, government sectors and critical sensitive sectors such as military and nuclear installation as well. The framework offers the ability to be extended further from a Minimum Service Level framework to medium or maximum secure service level framework depending on the needs of the business application and client end-user requirements. The framework provides the ability to be extended and special adds-on are incorporated to the existing model depending on the end-users and business sector requirements. The model has the ability to be used in all sectors and accommodate different user needs. With increasing number of cloud users and organizations there is a need of a comprehensive implementation model that is adaptable and cater the needs of the end-user. The MSL framework provides an opportunity to implement cloud solution and has the ability to cater different needs of the users. For the future work the model should be tested in other sectors for its practical application and should be adapted to meet the specific requirements. The scope and application of the model is very large and can be widely used as a set standards for cloud computing implementation in various sectors.

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Appendix-I

Questionnaire (Students)

Introduction to Cloud Computing: The term "Cloud Computing" is defined by the National Institute of Standards and Technology (NIST) as "a model or enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, server, storage, applications, and services), subscription based service that can be rapidly provisioned and released with minimal effort or service provider interaction". The cloud computing model allows data to be hosted on a third party servers which will reduce the infrastructure cost and based on the subscription model the services will be offered to the end-users.

Important Application in Cloud Computing: There are major cloud applications that are in use today and play a vital role in-terms of connectivity and scalability. The examples of these applications are Microsoft Office 365, Google Apps, Dropbox. There are many major business names that are using the cloud computing service such as GoDaddy, Outlook Web Access, Adobe Creative, FedEx and Twitter.

Term: CIAA Triad. (Confidentiality, Integrity, Availability and Authentication).

Confidentiality: Data should be kept secret and only authorized person can access data with due legal permission.

Integrity: Data is correct and real. The data can be trusted and only authorize person can access or modify the data.

Availability: Data and all services are available to authorized users to be accessed whenever and from wherever.

Authentication: Verifies the end-user is an authentic user and authorize to access the resources.

Q1: Are you familiar with the cloud computing technology?

- ○ Yes
- ○ No

Q2: Can you identify a cloud computing service?

- ○ Yes
- ○ No

If the answer is Yes. Please state the service.

Q3: Do you know whether your university is officially making use of third party cloud computing services?

- ○ Yes
- ○ No
- ○ Don't Know

Q4: Are you aware of the following functional areas does your university use third party cloud services? You may select multiple options if applicable.

- ☐ Accounting and Financial Administration
- ☐ Application Development

- ☐ Calendaring
- ☐ Campus Administration
- ☐ Email
- ☐ Helpdesk
- ☐ Human Resources
- ☐ Legal
- ☐ Library
- ☐ Public Relations
- ☐ Research
- ☐ Student Administration
- ☐ Web Hosting
- ☐ Other (please specify)

Q5: What is your perception in the motivation for the adoption of Cloud Computing in HE institutions? Rank any following THREE in the priority by writing 1,2,3 in the option.

- ☐ Cost Reduction
- ☐ Elasticity
- ☐ Support your studies
- ☐ Flexibility
- ☐ Rapid Deployment

- [ ] Security
- [ ] Quality of Service (QoS)
- [ ] Technological Evolution

Any other?

Q6: What you consider as a main concerns regarding the use of cloud computing in the HE institution? Rank any following THREE in the priority by writing 1,2,3 in the option.

- [ ] Security Issues
- [ ] Quality of Service (QoS)
- [ ] Legal Issue
- [ ] Privacy Concern
- [ ] Compliance and Standard Issues
- [ ] Availability Standards
- [ ] Audit Mechanism Concern
- [ ] Organization and Cultural Change Issues
- [ ] Skill Shortage
- [ ] Technological Issues

Any other?

Q7: What aspects of cloud computing you think will improve your day-to-day working and ensures smooth adoption of cloud technology in the HE institution? Rank any following THREE in the priority by writing 1,2,3 in the option.

- ☐ Security Issues
- ☐ Quality of Service (QoS)
- ☐ Legal Issue
- ☐ Privacy Concern
- ☐ Compliance and Standard Issues
- ☐ Availability Standards
- ☐ Audit Mechanism Concern
- ☐ Organization and Cultural Change Issues
- ☐ Skill Shortage
- ☐ Technological Issues

Any other?

Q8: Did Cloud Computing implementation in HE institution met your inspirations and requirements?

- ☐ Yes
- ☐ No

If the Answer is No. Provide Explanation

Q9: Can you propose solutions to the barriers or challenges in the adoption of the cloud technology and how its daily operation can be improved?

- ☐ Security and Privacy Issues
- ☐ Legal Issues Expert
- ☐ Audit and Compliance
- ☐ Quality of Standard and Service Assurance
- ☐ Technology knowhow
- ☐ Cloud Computing Market Knowledge
- ☐ Availability and Integrity Issues
- ☐ Authorization and Authentication Standards
- ☐ Complexity reduction
- ☐ Cultural Change
- ☐ Interoperability Standards

Appendix II
Questionnaire (Staff)

Introduction to Cloud Computing: The term "Cloud Computing" is defined by the National Institute of Standards and Technology (NIST) as "a model or enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, server, storage, applications, and services), subscription based service that can be rapidly provisioned and released with minimal effort or service provider interaction". The cloud computing model allows data to be hosted on a third party servers which will reduce the infrastructure cost and based on the subscription model the services will be offered to the end-users.

Important Application in Cloud Computing: There are major cloud applications that are in use today and play a vital role in-terms of connectivity and scalability. The examples of these applications are Microsoft Office 365, Google Apps, Dropbox. There are many major business names that are using the cloud computing service such as GoDaddy, Outlook Web Access, Adobe Creative, FedEx and Twitter.

Term: CIAA Triad. (Confidentiality, Integrity, Availability and Authentication).

Confidentiality: Data should be kept secret and only authorized person can access data with due legal permission.

Integrity: Data is correct and real. The data can be trusted and only authorize person can access or modify the data.

Availability: Data and all services are available to authorized users to be accessed whenever and from wherever.

Authentication: Verifies the end-user is an authentic user and authorize to access the resources.

Q1: Are you familiar with the cloud computing technology?

- Yes
- No

Q2: Can you identify a cloud computing service?

- Yes
- No

If the answer is Yes. Please state the service.

Q3: Do you know which of the following user populations, within your university, have exerted the most pressure to move towards the cloud?

- Academia and Research
- IT department
- External Competition Pressure
- Management
- Technological Evolution
- Students
- Government Initiative
- Other (please specify)
- Don't Know

Q4: What is your perception in-terms of the benefits that can be experienced in the usage of cloud computing technology in the HE institution? Rank any following THREE in the priority by writing 1,2,3 in the option.

- ☐ More flexibility
- ☐ Quality of Service (QoS) and Standards
- ☐ Cost Saving
- ☐ Business Strategic Goals
- ☐ Complexity reduction
- ☐ Availability Standards
- ☐ Interoperability
- ☐ Green IT
- ☐ Advanced Technology
- ☐ Improve Security

Any other?

Q5: What you consider as a main concerns regarding the use of cloud computing in the HE institution? Rank any following THREE in the priority by writing 1,2,3 in the option.

- ☐ Security Issues
- ☐ Quality of Service (QoS)
- ☐ Legal Issue
- ☐ Privacy Concern
- ☐ Compliance and Standard Issues
- ☐ Availability Standards
- ☐ Audit Mechanism Concern
- ☐ Organization and Cultural Change Issues
- ☐ Skill Shortage
- ☐ Technological Issues

Any other?

Q6: Will you consider moving HE institution critical systems to the cloud computing technology?

- ☐ Yes
- ☐ No

If the Answer is No. Provide Explanation

Q7: In your opinion; which of the following standards there is a less support in the Cloud Computing Market?

- ☐ Legal Issues Expert
- ☐ Audit and Compliance
- ☐ Quality of Standard and Service Assurance
- ☐ Technology knowhow
- ☐ Cloud Computing Market Knowledge

Any other?

Q8: What aspects of cloud computing you think will improve your day-to-day working and ensures smooth adoption of cloud technology in the HE institution? Rank any following THREE in the priority by writing 1,2,3 in the option.

- ☐ Security Issues
- ☐ Quality of Service (QoS)
- ☐ Legal Issue

- ☐ Privacy Concern
- ☐ Compliance and Standard Issues
- ☐ Availability Standards
- ☐ Audit Mechanism Concern
- ☐ Organization and Cultural Change Issues
- ☐ Skill Shortage
- ☐ Technological Issues

Any other?

Q9: Did Cloud Computing implementation in HE institution met your inspirations and requirements?

- ☐ Yes
- ☐ No

If the Answer is No. Provide Explanation

Q10: Can you propose solutions to the barriers or challenges in the adoption of the cloud technology and how its daily operation can be improved?

- ☐ Security and Privacy Issues
- ☐ Legal Issues Expert
- ☐ Audit and Compliance
- ☐ Quality of Standard and Service Assurance
- ☐ Technology knowhow
- ☐ Cloud Computing Market Knowledge
- ☐ Availability and Integrity Issues
- ☐ Authorization and Authentication Standards
- ☐ Complexity reduction
- ☐ Cultural Change
- ☐ Interoperability Standards

Appendix III

Interview

Interview (Senior Management and Technical Staff)

Introduction to Cloud Computing: The term "Cloud Computing" is defined by the National Institute of Standards and Technology (NIST) as "a model or enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, server, storage, applications, and services), subscription based service that can be rapidly provisioned and released with minimal effort or service provider interaction". The cloud computing model allows data to be hosted on a third party servers which will reduce the infrastructure cost and based on the subscription model the services will be offered to the end-users.

Important Application in Cloud Computing: There are major cloud applications that are in use today and play a vital role in-terms of connectivity and scalability. The examples of these applications are Microsoft Office 365, Google Apps, Dropbox. There are many major business names that are using the cloud computing service such as GoDaddy, Outlook Web Access, Adobe Creative, FedEx and Twitter.

Q1: What is your level of awareness or knowledge about cloud computing technology? Rate your knowledge from 1 (Low) to 5 (High).

1	**2**	**3**	**4**	**5**
Low		**Middle**		**High**

Q2: Which functional area you are using in the HE institution that has implemented Cloud Computing technology? What is your experience using the cloud technology?

_____
_____
_____
_____
_____
_____

Q3: What do you think are the main factors that should be considered during the adoption of cloud technology in the HE institutions? State any 3 factors in the priority.

_____
_____
_____
_____

Q4: What is your perception will cloud computing technology can help the HE institutions to achieve its strategic goals?

Q5: What you consider can be a major barrier to the adoption of cloud technology in the HE institutions? State any 3 barrier in the priority.

Q6: Do you feel confident moving your critical systems towards cloud computing technology? Provide Explanations to your answer.

Q7: Did implementation of cloud technology in the HE institution meet its strategic goals and delivered services according to the perception and motivation of all the stakeholders?

Q8: Can you suggest or recommend how to improve the adoption and implementation of cloud computing technology in the HE institution? State any 3 recommendations in the priority.

_____
_____
_____
_____
_____
_____

Q9: Is there any other issue that you want to suggest that is relevant to the cloud computing implementation in HE institutions?

_____
_____
_____
_____
_____
_____

Appendix IV- Interview – Qualitative Statement

Q1: What is your level of awareness or knowledge about cloud computing technology? Rate your knowledge from 1 to 5.

1	2	3	4	5
Low	**Satisfactory**	**Middle**	**Confident**	**Highly Confident**

Answers: Out of 20 respondents, the overwhelming majority of responses indicated confident or highly confident level of awareness and knowledge related to cloud computing technology whereas only 4 respondents indicated middle or satisfactory level as their responses.

Q2: Which functional area you are using in the HE institution that has implemented Cloud Computing technology? What is your experience using the cloud technology?

MT1: *We are using cloud technology in the Email System and level of service is better than before in-terms of availability.*

MT2: *The technology has large benefits to our HE institutions. In some areas we have experienced major improvements such as our Email System, Help Desk Management and some front line services. There are areas which have not seen considerable improvement such as supporting intensive research, legacy systems, Web hosting services.*

MT4*: We have moved our attendance system on cloud technology and it is working fine with very few issues reported so far*.

MT6: *Application Development is an area for the concern. The quality of service offered by cloud technology is not consistent and I keep getting complains due to poor quality of service availability issues and lack of processing ability. The interoperability is a problem as we have old legacy systems and they cannot operate on the new platform over the cloud.*

MT9*: Some functional areas we had huge barrier to integrate the cloud technology due to legacy system as the new technology doesnot support it. Also there are major concerns*

regarding the data security, data privacy by various quarters in the HE institution as there is a lack of assurance from the provider.

MT11*: Web Services Hosting and Enrolment online is using the cloud services. We have major issues with massive delay to complete the transactions. The students kept complaining that it was taking too long to complete the enrolment process especially when there is peak for student enrolment.*

AT1: *The cloud technology is being used to support our Research Departments as we require large processing power to support our research. The quality of services is variable without consistency. It doesnot meet our expectation.*

AT2: *Use of technology to support web hosting was not a good experience as the system was not available and have major problems in terms of availability. Some days there is no issues and everything runs without any problems whereas on other days we have problems.*

AT3: *There are issues in-terms of variable quality of service offered by the technology while used for support various applications.*

TS1: *The move from traditional inhouse model to cloud technology have serious concerns such as data security, privacy, availability as there is lack of guarantee from the service provider.*

TS2: *Use of cloud technology to support Research and Development project have a poor quality of service with variable standards of QoS (Quality of Service).*

TS3: *The use of cloud technology for online admission process was a major problem as there was a huge delay with multiple complains raised by students. The service was not consistent.*

Q3: What do you think are the main factors that should be considered during the adoption of cloud technology in the HE institutions? State any 3 factors in the priority and justify you selection.

MT2: *The main factors what I think should be considered during the adopting of cloud computing technology for HE institution is 1: Guarantee to consistent quality of service being offered by the provider. This is core to the success of adoption of the technology, 2: Ensure that data will be protected from any breach and its integrity and confidentiality is not compromised with better layered security in-place to ensure this. The image of a business is badly damaged if there is breach of data and data security or privacy is compromised. These*

damages I considered as irreversible to any business and customer will never trust that organization. 3: Incident response from the provider is also crucial and should be considered during the adoption of cloud computing technology.

MT5. *For a HE institutions it is crucial to have consistency in-terms of the services we are providing. Our students demand that level of services should be excellent and consistent. So we should analyze whether the cloud technology can provide better services to our customers (students). If the technology can meet the challenges then it should be adopted in any institution. The second factor that I considered crucial in the adoption of cloud technology of HE institution is reduction of cost for the entire operation. The overall budgets are getting squeezed and value for money is very important. We need a technology that can reduce the overall cost and it the same time provides data security and privacy standards. The third factor that should be considered in the adoption of cloud technology is the CIAA triad. The question is whether the technology can provide data security, integrity, availability and privacy standards as there can be provide good services to our students, staff and overall community.*

MT7: *My preference is whether the technology will provide a better quality of service and at the same time we can reduce the cost as well. Also the technology can provide sound security, privacy with layers of system to ensure that HE data is kept secure and no unauthorized person can access data. In the next factor that should be considered is the audit and security mechanism of the cloud service provider. Before the adoption of cloud computing technology it is crucial to examine what procedures and safeguards are in-place by the cloud service provider to avoid the inside attack or accidental leakage of data as the resources are being used by many clients. We are also worried about the internal attacks and that can affect the overall quality of service and lead to data breaches.*

MT10*: Three main priorities that I considered the most important in the adoption of cloud computing in the HE institutions is offering a reliable, secure technology that can offer better level of services for our students. The technology can help to reduce the cost but at the same time offers better processing speed, network throughput, and availability and help the HE institutions to achieve their objectives.*

MT12: *For me, the new technology should be aligned with our strategic objectives that we set for the HE institutions. The strategic objectives is to ensure a technology that can allow us to compete effectively in the 21st century by providing robust system that can ensure effective, reliable, secure services ensuring that advanced technologies are supported to meet the ever changing market requirements. The technology can improve productivity and efficiency by proving a technology that is always available to our students and reduce the overall expenditure. The migration of data to the cloud platform is a major challenge as we are experiencing issues with the moving legacy systems to the cloud platform.*

AT1: *The technology should support the teaching and learning activities in the HE institutions. The main priority should be a state of art technology that provides best quality of service, high processing, with high availability, with security and privacy to our data as it will be stored on a third party servers. The technology should support our research activities that we are conducting across various partners that are geographically divided. The other factor which should be considered is the storage location of sensitive data and mechanism to ensure that all policies are followed by the provider and are verified by a third party.*

AT3: Three *Main factors that are important according to me is a technology that can reliable and available every day to support our operations. Data is secure and we have guarantee to the quality of services that will be offered so there is no issues later on. Third party audit of the cloud service provider facilities to ensure that provider is following all policies and procedures.*

TS1: *We need a technology that provides consistent quality of service that provides high availability rate. The technology is easily deployed in the HE institution and provide us with the flexibility to integrate other technologies with cloud model without any issues in-terms of portability and interoperability. The next factor is the incident response mechanism and response time from the cloud provider should be considered before the adoption of cloud technology.*

TS2: *Data security, data privacy, integrity of data with flexibility to shift from the traditional technology to the cloud technology are the main priorities in the adopting of cloud technology in the HE institution. Data governance strategy is also important as we need guarantee that the data will be stored securely and the service level agreement need to provide strong guarantee.*

TS3: *As we are storing data on the third party using the cloud technology it is crucial to ensure that data security, privacy, confidentiality and its availability of service should be guaranteed to the HE institution. This assurance can provide guarantee that should be in-place while adopting the cloud technology. The portability and interoperability is a major issue for any organization and should be considered before the adoption of cloud computing technology*

Q4: What is your perception will cloud computing technology can help the HE institutions to achieve its strategic goals?

MT2: *I'm very confident that the adoption of cloud technology in the HE institution will enable us to achieve our strategic goals to provide a better quality of service that provides security, confidentiality to our data. The technology provides us a competitive advantage*

over our competitors to use more advanced technologies, perform advanced research, services are available to the end-user all the time and performance of the technology will provide a rich learning experiences to our students.

MT5*: I have heard a lot of hype about the cloud computing technology and I'm hoping that the technology will provide a platform that will allow us to meet our long term goals that provide a guarantee to quality of services with systems in-place to ensure security, privacy and high standards of availability. So far we are facing issues in-terms of service availability as there service outages reported which us concern for us.*

MT9*: We are facing a massive budget constraints due to changes in the public spending reduction. With the use of cloud technology we will be able to reduce the overall spending in technology that will allow us to meet one of our strategic goals. There are concerns related to data security and privacy in which we still require strong guarantees from the service provider.*

MT12: *HE institution strategic goals require us to ensure reliable, secure and available service to our students, staff and research and all other data is kept and processed in save, secure and reliable manner. The strategic goals are to support the advanced research and enjoy the experience of processing large data sets and services are always available without any disruption. The technology should reduce the cost and allow the flexible transition from the traditional model to the cloud model. We expect the cloud model should enable us to meet those goals.*

AT1: *The cloud computing technology in the HE institution will ensure to provide rich learning environment to our students so they are ready for the real world challenges. At the same time the technology can ensure smooth and effective collaboration between our HE institution and other institutions to support research and development.*

AT2: *Our strategic goals dictate that we need to provide an excellent and reliable service to our students that ensures that students, staff, research data is kept and processed in save, secure and reliable manner. Provides guarantee of services. Researchers can conduct advanced research and enjoy the experience of processing large data sets and services are always available without any disruption. The technology should reduce the cost and allow the flexible transition from the traditional model to the cloud model.*

TS1: *The main strategic goals is to provide a quality of service that ensure the data is stored and processed securely and its privacy is maintained. Also we can reduce the cost, provides flexible transition journey and provide a technology that can allow HE institution to meet the challenges of the 21st century. In case of an incident we can expect the cloud service provider*

to resolve the incident quickly and allow all old and new systems to function without any problem. We are hoping that the cloud technology can help us to meet all these objectives.

***TS3**: We are confident that the adoption and use of cloud technology will help the HE institution to meets its strategic goals to provide an advanced technology that provide a guarantee level of services in-terms of better quality of service, data security and support research work.*

Q5: What you consider are major barrier to the adoption of cloud technology in the HE institutions? State any 3 barrier in the priority.

MT1: *The major barrier in the adoption and implementation of cloud computing technology in the HE institution was a lack of standards or lack of service level framework that allow the end-users to compare and select the service that is required, also a framework that provides a guarantee to the level of services that will be offered by the cloud provider. We at the HE institution struggle to find any level of framework that provides a guarantee to a level of services that can set standards to the cloud computing industry. The second barrier we faced is quality of services offered is not consistent and there is no benchmark to measure the performance of all the cloud provider against this set of standards or parameters. The next barrier was surrounded around the security and privacy of data. The level of security of different cloud providers was not providing the assurance that we demanded to protect and secure our data. This was a concern as some of the providers practices were really a matter of concern. I would like to add another barrier which was the understanding of the technical service level agreement. We struggle to understand the contracts that are very complex in the nature with legal and technical terms which created a major problem for understanding. Also the cloud industry is not there to support the potential new users with shortage of skilled staff as major barrier in the adoption of cloud computing technology.*

MT2: *Lack of quality of services offered by various providers according to me was major barrier to adoption and implementation of cloud computing technology in the HE institution. The standards of data security, data access, confidentiality, availability, audit mechanism and legal issues is based on variable level of services that depends on each cloud provider. Some providers support detailed layered security with audit mechanism to have an extra layer of check whereas other providers are not robust in their processes. The next barrier was lack of advice and support that is available in the cloud market regarding the legal issues and there is shortage of skills sets that creates a major barrier in the adoption of cloud services. There are not enough cloud expert skilled workforce available for smooth transition towards cloud environment.*

MT6: *According to me the major barrier in the adoption of cloud technology in the HE institution is issues related to confidentiality of data, Integrity of data, privacy of data, availability of data and accountability to secure the data. The level of services offered is this regard are lacking and are cause of serious concerns. Lack of third party audit, and variable incident response mechanism are also a barrier to the adoption of technology. The cloud industry should have a mechanism or a framework which can ease the selection of the cloud service and reduce the technical jargon will be a suitable step in improving the adoption of cloud computing technology.*

MT10: *Poor quality of services, lack of uniform model or framework that sets the benchmark for the cloud providers and data security and privacy are they 3 barriers in the adoption of cloud technology in the HE institution.*

MT12*: I'm concerned about lack of audit mechanism to ensure that all data is kept securely by the third party cloud provider. In my opinion it is major barrier as we will not able to inspect these cloud remote sites and without a detailed third party independent audit how we can ensure that data is saved, processed securely. The next barrier is the lack of transparent framework that set a benchmark to the level of services to the cloud provider. Also we faced some resistance internally from the staff as they were worried to move towards the cloud technology due to job losses. The next adoption challenge is the lack of governance framework which can provide us with the detail of data governance mechanism and site security procedures. This information is not provided by the cloud service provider and for me as a major concern.*

AT1*:* *According to me the top of these barrier will be the lack of standards in-terms of availability of services. As I'm involved in the advanced research and our requirements are to process large data sets. We have struggled a lot to have the services always available at a good standards that can support the processing of data. The second barrier is nonexistence of set standards that can demand a good quality of services and all providers are compared and evaluated according to these set parameters defined in a framework. That is the reason now providers can offer different level of services that cannot be benchmarked and doesnot meet the customer's requirements or help us to compare the performance of each provider. I'm also concerned about the data security, privacy and lack of accountability on the part of cloud providers as there are multiple examples of data leakage that have taken place in the recent past and there should be a mechanism which should be independent to verify the level of facilities and procedures followed by the cloud service provider at their cloud storage site.*

AT2: *Three barriers are lack of standards, concerns about data security, data privacy, and poor audit mechanism are creating problem in the adoption of cloud technology in the HE institution.*

AT3: *Portability of the old legacy system towards the cloud platform is a major barrier for us. We cannot move our old data and systems on the cloud platform which is hinders to the adoption of cloud computing technology.*

TS1: *We struggled to find a provider that can offer a quality of services that they are ready to provide solid guarantee. There was no benchmark or standards where we can compare one provider with another provider to assess and compare the level of services. This delay the entire process a lot. The next barrier was lack of comprehensive systems to ensure security, privacy to data from different providers. The situation is also concerning as a cloud users as there is lack of third party audit mechanism which is a concern to the adoption of cloud technology in the HE institutions. According to me these barriers have to be address so that we can feel comfortable and overall cloud adoption rate will increase.*

TS2*: Legal issues, lack of standards and poor quality of services are major barriers in the adoption of cloud technology in the HE institution.*

TS3: *Skills shortage of staff is barrier and needs training so that cloud technology can smoothly adopted. The internal staff at the HE institutions never liked the change towards cloud technology as there are also barrier to the adoption of cloud technology. There are concerns in-terms of job security as well. Concerns are related to data security, and privacy challenges.*

Q6: Do you feel confident moving your critical systems towards cloud computing technology? Provide Explanations to your answer.

MT3: *In my honest opinion I don't feel confident and comfortable to move the critical financial systems other critical core functional areas towards cloud computing due to various issues such as data security, privacy and variable quality of services offered by the provider. The situation can change but so far this is my professional advice don't move the critical applications and data to cloud platform.*

MT4: *No. If it is third layer systems to move towards the cloud platform that is ok. But moving the critical systems towards the cloud platform we are not comfortable with this so far at this time. There are multiple reasons to my decision which are, as we have come across data security breaches in cloud providers, issues such as internal theft and procedure to safeguard against it is not clear, lack of oversight in-terms of third party audit, lack of standards or benchmark that industry has to follow to provide consistent quality of service are not available. So I will wait and see what industry will do to address these issues. So far let's wait until all these mechanisms are in-place before this big move.*

MT5: *I will hesitate to move critical HE systems to cloud computing provider at this moment of time. We are using third party cloud technology for some of the front line non-critical systems but until we receive 100% guarantee to data security, data privacy, data integrity, data availability, with layered security and oversight by third party audit and full protection by legal law we should not make the move towards moving the critical systems to cloud technology.*

MT8: *This worries me a lot and I'm totally against moving the critical systems to cloud technology as we speak. This decision can only change if we are provided by a framework that provides guarantee to the quality of services that we desire to see in-terms of set parameters that cloud provider have to provide service against and all of them will be measures against those set layout parameters. These parameters should dictate availability standards, data security, privacy assurances standards, layered security to protect our data, detailed mechanism on internal processes, detailed support on legal issues, authentication standards, accountability of cloud providers if they don't deliver the service they promise and to oversight to all this can be done by a third party audit mechanism. Until these standards are not in place moving the critical HE systems can be very detrimental to the organization.*

MT10: *I would like to see a framework or a model that can help to select the cloud provider easily and evaluate their service by making them accountable. We need to see the procedures and policies that are followed by cloud provider and a third party to verify this. Until this is not done we should avoid moving critical systems to the cloud service provider.*

AT2: *Critical Systems no way at this time. We still need assurance on data security and privacy standards and how our data will be secured on a third party servers.*

AT3: *I will be worried for our data security if the critical systems are moved to third party cloud providers. I cannot see this happening until the cloud industry address our concerns such as consistent quality of service throughout the industry, set of standards that everyone as a cloud provider has to follow, and deal with data security and shortage of trained staff.*

TS1: *Sorry this is not safe at this moment to move our critical systems over the cloud. The level of services offered by the providers in the cloud industry has to improve with benchmark or framework that set standards for everyone to follow in the cloud industry. As we speak the cloud industry is failing to provide a uniform framework or a level of service which can assure that quality of service.*

TS3: *We are not ready for this. There are serious concerns already that have been raised to move non-critical systems in the HE institutions towards cloud technology as we face erroneous problems already. Moving critical system is out of option as there are serious concerns regarding rapid deployment, lack of third party verification, CIA triad issues are major concern and variable level of service offered by cloud industry.*

Q7: Did implementation of cloud technology in the HE institution meet its strategic goals and delivered services according to the perception and motivation of all the stakeholders? Explain your answer.

MT1: *So far we are not able to meet our strategic objectives that were set with the implementation of cloud computing in the HE institution. The level of service is not meeting our expectation or perception we had. The areas of serious concerns as the quality of service offered as compared to promised as there is a major mismatch in-terms of lack of standards or framework to measure the performance or make the providers accountable or compare the performance with other providers, serious data security and privacy issues with recent data breaches has affected the potential cloud user's confidence. Incident response time is also a concern for us as a cloud users and we as HE institution cannot afford to have delay on this. The level of service is variable and not consistent across the cloud industry.*

MT8: *I don't think so as we are way from our strategic goals and our current position even after the implementation of cloud technology in the HE institution. The reason is that the variable quality of service has been reported from various department multiple times. Issues such as moving the old legacy system towards cloud has come to massive barrier as the cloud platform doesnot support to run our legacy system. Concerns regarding the data availability has been raised by our users and issues such as lack of transparency at the end of cloud provider in-terms of data security standards, data governance framework and site security issues have been a concern for us. There is a lack of accountability to measure the performance of the cloud service provider.*

MT9: *Not at all. The recent concerns regarding the data breaches is affected everyone in the HE institution in a negative manner. The level of service offered is not meeting the desired expectation. Issues such as lack of third party audit and poor incident response mechanism are major concerns.*

MT10: *We are far behind then our strategic goals that were set for the HE institution. I have serious concerns regarding the audit mechanism to ensure that cloud provider is taking all the necessary steps to secure and protect our data. Also the service is not consistent and availability issues are the concern for those functional areas that have used cloud computing with many problems reported.*

MT12: *I'm worried that the strategic goals set for the HE institution and our current status is far apart. Our Research and Development department was not able to process large bulk of data set and there is delay in the research due to poor availability of services from the cloud provider. There are concerns regarding the data governance framework and issues such as lock-in with the provider. We need an option to move to another provider whenever we desire to do so rather than locked-in with the provider. My point of view is cloud providers are not being held accountable as there is a lack of agreed standards by which we can measure their performance, compare the quality of service they are offering and then make them accountable.*

AT1: *We have made some progress but meeting all the strategic goals with the adoption of cloud technology we are not at that point right now. The cost reduction is on-track but the quality of services offered doesnot meet our expectation. Still concerns related to data security, privacy, integrity and authentication are not addressed. There is a lack of accountability to measure the performance of the cloud service provider. We would like to have a third party to monitor the cloud provider data centre but there is no mechanism right now that can enable this.*

AT2: *So far not. I'm hoping that we can get to that point soon where the cloud technology can help us to meet our strategic goals by supporting advanced highly data intensive research, provide quality of services that meets the expectation of students and staff, provide layered security to our data, provide guarantees that internal security is fool proof, support for legacy systems in-place and audit mechanism to check and verify the processes that are used by the cloud providers in their data centres'. We have concern of lack of transparency, lack of accountability, data security and variable incident response mechanism.*

Q8: Can you suggest or recommend how to improve the adoption and implementation of cloud computing technology in the HE institution? State any 3 recommendations in the priority.

MT1: *The problem we faced is the selection of the cloud providers as everyone was offering various level of service or standards and there was no benchmark that we can compare the quality of service with. While adoption the cloud service provider going through the service level agreement there was a lot of technical details that was very confusing and consist of technical and legal terms which we were not able to understand or able to compare the services offered by one provider against another cloud provider in the absence of a framework. If the cloud industry has to improve they need a selection framework that set some standards which every provider has to adapt and offer. This will allow easy selection of the cloud provider also guarantee of the quality of service. The next major recommendation that I will suggest is providing full assurance on data security and data privacy as large amount businesses are worried about their data security, privacy. We need to have consist incident response mechanism as well which is required.*

MT2*: Three main recommendations to improve the adoption and implementation of cloud computing technology is to provide guarantee to provide better Quality of Service(QoS). The standards of service should meet the client requirements such as data security, data privacy standards, data should be available to our students all the time, provide technical support quickly, offers layered security and allows an audit mechanism that offer an oversight to the entire process which is independent in nature. As we speak all cloud providers are offering variable standard of service with no fix standards in the industry so it is very complicated to move fully towards the cloud computing technology. There is a major concern related to legal issues and data privacy which need to be addressed so that the adoption rate of the technology can increase.*

MT4: *To improve the cloud adoption there is a critical need of framework that set certain rules that providers have to follow. This is not the case as we speak. It was a difficult task to select the cloud provider without these set parameters or framework. Issues such as third party audit need to be incorporated as we need an assurance from an independent third party that our data is secure and systems that are in-place are adequate at the cloud provider site. I also think it would be better to address service availability issues. As we move towards cloud technology if the service is not available then our entire operation comes to halt. Service availability needs to be improved. The governance and compliance framework should be transparent and easily accessible to its users so that we can clearly see the policies and procedures of the cloud service provider and are aware of site and data security mechanism.*

MT7: *The most important recommendation is to have set of standards that the entire cloud providers have to follow. These set of standards will be benchmark to be followed. These set of standards for the service offered will improve the level of service across the cloud industry and act as measuring scale to assess which cloud provider is better. Also it will help the cloud users to select the cloud providers based on these set parameters reduce the entire confusion. We need to improve the training and skills related to cloud computing as there is massive shortage in this area right now. Authentication and authorization issues need to be addressed as we have faced data breaches due to this weakness and issues related to data portability and interoperability need to get more importance.*

MT8: *There is a lot of misconception about cloud technology inside the organizations***.** *We faced a large resistance from our employees as they were not ready to accept the new technology. We need to address this issue so that there is smooth transition towards cloud computing technology. We need assistance in the legal issues as there is minimal support advice from the cloud industry. This is another major concern for us as we are not sure about this area. So the cloud industry and organizations have to work together to understand the implication of legal issues and avoid any issues in the future.*

MT10: *We are worried about data security, data privacy, integrity and insider attacks that can happen in the data centres. The cloud industry has to improve and provide better quality of services so that more business can move their operation to the cloud technology. I don't think so, as far as this is the case as businesses are worried to move their critical systems*

towards cloud technology until these issues are not addressed. We need to address legal and compliance issues, audit mechanism issues so that the overall confidence in the use of technology can increase.

AT1: *My three recommendations are 1: A framework that guarantee Quality of Service that allows potential cloud users to compare the performance of cloud providers with each other. 2: Data Security and Privacy concerns have to be address. 3: Independent Audit to ensure that standards are met. These three recommendation will improve confidence in the cloud providers and more the businesses will use the cloud services. If you don't mind I would like to add one more key theme to this which is the issues of portability and interoperability to be addressed which is major problem in our case as we are struggling to move our legacy systems to the new platform.*

AT2: *There should be accountability for the cloud providers if they don't offer the service they offered. This accountability will improve the standards and improve the level of service offered. We have experienced issues on legal side a lot and I can see this area has far reaching consequences. To improve the adoption of cloud technology it will be better to improve the understanding about the legal issues and its jurisdiction. Data life cycle, data storage, data removal should be explained and ease to change the cloud provider without any lock-in option should be a part of the service level agreement provided by cloud provider.*

TS1*: The support for legacy system need to be improved. We are facing a large problem moving our legacy systems towards the new cloud platform as there are issues with interoperability. The level of services offered by the providers across the cloud industry is also a concern and creates a large problem for selecting the provider. The need of the hour is a comprehensive framework that has to be followed by the providers and set standards.*

TS3: *The level and quality of services offered by the providers doesnot give us a guarantee to the level of service. There is different standards of services offered in-terms of data security, privacy and service availability is a major concern. Until the cloud users feel comfortable storing their confidential data on a third party server the cloud adoption rate will not achieve it real potential. At the same time staff training and organizational barrier to the new technology has to be addressed so that the staff embraces the new technology rather than make hurdles in its implementation. One more issue is the lack of support from the cloud industry and very few skilled labour work force is available, this is a cause of concern that needs to be addressed.*

Q9: Is there any other issue that you want to suggest that is relevant to the cloud computing implementation in HE institutions?

MT6: *New approach with new thinking with a new set of standards that offers better quality of services and guarantee the data security and privacy concerns of the cloud users is required.*

MT7*: Need more organizational training to address any technical or other issues.*

MT8: *Cloud computing can change the way we work and interact with technology. The need of an hour is to have set standards and parameters that will improve the overall quality of services and improve the confidence of use the technology for the critical business functions.*

MT9: *The implementation of cloud technology in the HE institution so far has success and failures. We need to address some issues such as data security, privacy, integrity, availability and authentication so more users feel comfortable with the technology***.**

MT11: *My suggestion would be to have set of standards that can allow to compare the services offered by one cloud provider against another cloud provider. A comprehensive governance framework is required which ensure network, data, site security for the cloud infrastructure.*

AT1: *Service Availability, integrity, security of data concerns if addressed would improve the implementation of cloud computing in the HE institution.*

TS1*: Better understanding of the legal issues with a third party audit system in-place will help a lot.*

TS2: *Remote authentication concerns should be resolved. Data Security, privacy, data availability concerns should be resolved to smooth implementation of cloud technology in the HE institution.*

Appendix V- Cloud Computing Implementation Evaluation Criteria

	Minimum Service Level Framework		
	Minimum Standard	**Medium Standard**	**Enhanced Standards**
Data Security & Encryption Standard			
Authentication Standards			
Authorization Service Standards			
Incident Management & Reporting			
Interoperability & Portability Standards			
Identity Management Standards			
Data Availability Standards			
Data Governance & Compliance Management			
Data Protection & Legal Support			
Infrastructure Protection Standards			

	Minimum Service Level Framework									
	Minimum Standards									
	Data Security & Encryption Standard	**Authentication Standards**	Authorization Standards	Incident Mng & Reporting	Interoperability & Portability Standards	**Identity Management Standards**	Data Availability	Data Compliance	Data Protection	Infrastructure Protection
FIPS										
Format Encryption										
Stored Secure Hash										
Data Encryption Standard										
Revoke User Access										
Network Authentication										
Password Management										
WS-Security										
Role Management										
% of Timely Incident Reports to Customer										
Hardware Virtualized										
RAID 1										
RAID 2										
Policy Management										
Vendor Management										
Problem Report										
Data Obscuring										
Data Seeding										

HIPS/ HIDS										
Content Filtering										
Wireless Protection										
Application Firewall										

Minimum Service Level Framework										
Medium Standards										
	Data Security & Encryption Standard	**Authentication Standards**	Authorization Standards	Incident Mng & Reporting	Interoperability & Portability Standards	**Identity Management Standards**	Data Availability	Data Compliance	Data Protection	Infrastructure Protection
FIPS										
Format Encryption										
Stored Secure Hash										
Data Encryption Standard										
AES 128										
Key Access Policy										
Revoke User Access										
Network Authentication										
Password Management										
WS-Security										
Digital Certificate										
Smart Cards										
Role Management										
Entitlement Review										
Principal Data Management										
% of Timely Incident Reports to Customer										
Classification of Incident										
Hardware Virtualized										

Encrypt data before Sending										
Compatible database										
Domain Unique Identifier										
Federated IDM										
RAID 1										
RAID 2										
% Successful Request Processed										
Backup Generators										
Policy Management										
Vendor Management										
Problem Report										
Technical Awareness										
Service Failure Report										
Data Classification										
Data Obscuring										
Data Seeding										
Data Masking										
Data Tagging										
HIPS/ HIDS										
Content Filtering										
Wireless Protection										
Application Firewall										

Host Firewall										
Link Layer Network										

	Minimum Service Level Framework									
	Enhanced Standards									
	Data Security & Encryption Standard	**Authentication Standards**	Authorization Standards	Incident Mng & Reporting	Interoperability & Portability Standards	**Identity Management Standards**	Data Availability	Data Compliance	Data Protection	Infrastructure Protection
FIPS										
Encrypt II										
Key Access Policy										
Cryptographic Hardware										
Content Aware Encryption										
Format Encryption										
Stored Secure Hash										
Object Security										
Hide Privilege Access										
Data Encryption Standard										
AES 128										
AES 192										
AES 256										
Encrypt Log Files & meta data										
Revoke User Access										
ISO/IEC 29115										
Entity Authentication Assurance Framework										
Digital Certificate										

3rd Party Authentication										
Network Authentication										
Password Management										
WS-Security										
SAML Token										
OTP										
Multi-Factor										
Network Authentication										
Smart Cards										
Biometrics										
Password Management										
OTB Authorization										
Middleware Authentication										
Role Management										
XACML										
Entitlement Review										
Principal Data Management										
(OTB) Authorization										
Policy Management										
Resource Data Management										
% of Timely Incident Reports to Customer										
% of Timely Incident Response										

% of Timely Incident Resolution										
Classification of Incident										
Hardware Virtualized										
Encrypt data before Sending										
Compatible database										
Open API										
Encrypt data in Transit										
Store unstructured data										
Domain Unique Identifier										
Federated IDM										
Identity Provisioning										
Attribute Provisioning										
RAID 1										
RAID 2										
RAID 1 + 0										
Level of Uptime 99.999%										
% Successful Request Processed										
Return Point Objective (15 Minutes)										
Return Time Objective (15 Minutes)										
Maximum Data										

Restoration Time (30 Minutes)										
Backup Generators										
99.95% Successful Data Restoration										
Policy Management										
Compliance Management										
Vendor Management										
Audit Management										
Problem Report										
Technical Awareness										
Service Failure Report										
Key Indicator Report										
Data Classification										
Problem Report										
User Satisfaction Report										
Data Classification										
Data Deletion Type										
% of timely effective Deletion										
Data Obscuring										
Meta Data Control										

Data De-Identification										
Data Masking										
Data Tagging										
Data Seeding										
Data Obscuring										
E-signature										
HIPS/ HIDS										
Malware Prevention										
Whitelisting										
Content Filtering										
Wireless Protection										
Application Firewall										
Host Firewall										
Link Layer Network										
Media Lockdown										
XML Appliance										
Real Time Filtering										
Application Firewall										