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An E-Learning Architectural Framework for Nepal Using Cloud Computing and Satellite

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Abstract: ***With the advent of Information Technology, it has been used for different applications including E-Learning. E-Learning activities have been prevailed across the World especially after the CODID-19 pandemic while almost all the academic Institutions were physically closed. Back then, Cloud Computing was also popular which is one of the significant branches of Information Technology applied in various fields of human life. Academic Institutions like schools, colleges, Universities and Research Intuitions use Cloud Computing Technology to store and access their teaching learning materials for their students, teachers, researchers and administrative staff. Academic Institutions need not to buy computer technology including hardware and software and no issue of upgrading them to use in their Institutions. They can hire the different Cloud Services in Pay per Use provision with Service Level Agreement (SLA). The Academic Institutions can buy hardware, working platform and application software as required and no issue of technology up gradation and software license due to the use of Cloud Virtualization Technology. The academic Institutions can setup their own Private Cloud for the local teaching learning materials and it can be connected with Public Cloud to get the additional facilities. The research has also included the use of Cloud computing in academic Institutions in different developing countries in Asia and developed country like United States of America (USA). E-Leaning is very relevant in Nepal to conduct virtual classes at the time of political disturbances, natural disasters and at the time of Pandemics. The Academic Institutions in city area of the country can run physical classes and their virtual classes simultaneously to access the quality education for the students who study in the rural areas of Nepal. The research includes the solution for those students who do not have access of sufficient Internet BW and no Internet service at all can use Ku Band Satellite downlink for the E-Learning video simultaneously.***

Keywords: Cloud Computing Technology, Cloud Virtualization, E-Learning, Cloud Services, Cloud Deployment, Ku Band Satellite

1. Introduction

The teaching learning activities are changing over time with the development of Internet technology. In the ancient time, students used to gather at teacher's residence for the education to be expert in a particular subject and skill. Then schools, colleges and universities were established for the educational purposes. Students enroll in the academic institutions to get the education in different subjects and faculties. The teachers teach their subjects to the students gathering in a class.

With the development of Internet technology, the teaching learning pattern has changed from physical to virtual classes. There are different academic institutes in the World running distance education using Internet and applications specially for those students who cannot attend the physical classes due to financial and time bound reasons.

The main aspect of use of Cloud computing for E-learning is use of remote computer infrastructure in very low price to store teaching-learning materials and access at home. Cloud Services like IaaS (Infrastructure as a Service), PaaS (Platform as a Service) and SaaS (Software as a Service) are available at home with highly scalable manner in pay per use provision (Urs, Holzle, 2012). Personally or institutionally, the service is purchased as required and used for academic purposes in affordable price.

In Nepal, most of the people live in village areas where students do not get highly experienced and qualified teachers for education. The physical classes running in city area by highly qualified teachers can be accessed for students in rural areas simultaneously using the online class facility of the same physical class. Government has to initiate for that facility to access quality education for rural students. Internet Technology with video conferencing applications like Google's Zoom, Google's Meet, Microsoft's Team etc. are applicable for this purpose. In Nepal, we have frequent political disturbances and Academic Institutions are closed very frequently. In this time, the academic institutions can continue classes using online class and provide teaching learning materials, assignments and homework using Cloud Computing Technology. Apart from this, we have several other reasons to close the academic institutions quite often due to natural disasters like earthquakes, flooding, landslide and so on. Cloud-based e-Learning can compensate the course of the students who are deprived from the regular classes due to interruption of their physical classes.

The cost of Cloud Computing is too low in which virtual infrastructures are used in very low price. Academic Institutions need not to purchase high end hardware infrastructure and software with license. All required services are provided by Cloud Service Providers (CSP) using Server Virtualization in Cloud Computing. There are different types of clouds deployed like Private Cloud established and used by private organization, Public Cloud which is installed and operated by government, Hybrid Cloud is the combination of Private and Public Cloud and Community Clouds is installed and operated by a particular community to fulfill their needs (B. Patel & Kansara, 2021) . Academic Institutions can hire the Cloud services as per their requirements.

The E-Learning using Cloud Computing Technology is not only relevant in developing countries like Nepal, but also is prevailed in developed countries like US an UK too. The developing countries like India, Bangladesh, Pakistan, Turkey etc. are effectively using Cloud Computing Technology for E-Leaning (Alkidi et al., 2014). This technology became further popular during the Covid-19 pandemic duration. Nepal also did quite an enough practice of online classes including in village areas using Cloud Computing during COVID-19 pandemic duration. At the same time, universities of different countries were running online classes to their international students who were at home during the COVID-19 pandemic period.

To run E-Learning using Internet has Internet BW issue in Nepal. Nepal can be divided into Urban, semi urban and remote area in terms of availability of Internet BW. In the city area, there is sufficient Internet BW available, where E-Learning has no issue of Internet. In village areas, there is not sufficient Internet BW, so using Ku Band Satellite will be effective for the students to access the teacher's audio/video and VoIP channel for student's audio to ask the question to the teacher. However, teacher will answer through satellite channel to avoid the audio synchronization. For the remote area, students can get E-Learning class from satellite on TV set but there will be no interaction with teacher. The satellite downlink cost in Ku Band is nominal that needs a small receiving antenna and a set-top box.

1.1 Reasons of Using Cloud Computing in E-Learning

According to F. F. Ahmed (2015), there are different reasons why E-Learning has shifted to Cloud Computing Technology. Using Cloud Computing in E-Learning has the following advantages:

a) There are better facilities for planning and designing and organizing of the E-Learning materials.
b) Cloud Computing has been extensively used to design the distributed learning systems, Corporate, Universities, Virtual Universities and Cyber Schools.
c) Cloud Computing is much more friendly to use LMS (Learning Management System) for the students.
d) Cloud Computing provides better facilities client's preferred OSs, stable virtual machines, full redundant architecture, web-based console, firewall for security, compatibility with already running applications, and 24/7 technical services.
e) It also provides facilities of pay-per-use model, flexible in new design, transparency of services, no limits of the demand resources and no issue of backup power control.
f) Using Cloud Computing in E-Learning by academic Institutions need not to deploy their own infrastructure, no issue of IT support failover, no need to buy extra Hardware and software, no need to system configuration, coding, testing and update the latest technology, no need to manage extra power & cooling, no need to have project management team.

According to the study of MIT funding E-Learning Company, using Cloud Computing in E-Learning has several other benefits including financial cost. It reduces the Elicitation and gathering cost by 25%, IT Labour Cost by 40%, Testing Effort by 20%, Capital Utilization and Improvement cost by 65%, Technical IT support cost by 40% and overall Project Cost by (35-40) %. So, use of Cloud computing in E-Learning is drastically beneficial in terms of cost and other facilities.

Other advantages of using Cloud Computing in E-Learning are that increases the high storages capacity, facilities of automation system, flexibility, mobility, sharing of resources, develops business agility and has strong backup, and disaster recovery package, (Baharuddin et al.; 20121).

2. Literature Review

2.1 Definitions of Cloud Computing

There is no any unique definition of cloud computing because of the changing technology and vast scope of use of Cloud Computing Technology in the modern era. Cloud Computing is the process of using different computing services like hardware, storage, network, software applications etc. from remote location. However, there are several definitions given by experts which are given as below:

NIST: "Cloud Computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e. g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. " [Mell & Peter, Grance, Timothy, 2012]

Forrester: "A pool of abstracted, highly scalable and managed computing infrastructure capable of hosting end-customer applications and billed by consumption. " [Aldhawan, Nouf S., Ramzan, Muhammad S., 2022]

Gartner: "Cloud Computing is a style of computing where massively scalable IT-enabled capabilities are delivered as a service to external customers using Internet Technologies. " [Alkidi, Z. S., Haynes, Arockiasamy, 2014]

There are several other definitions of Cloud Computing in the article "Descriptive Literature Review and Classification of Cloud Computing Research" as give in the Table 2.1.2 as below: [Aldhawan, Nouf S., Ramzan, Muhammad S., 2022]

Table 1: Definitions of Cloud Computing

S. N.	Definitions	References
1.	The illusion of infinite computing resources available on demand, the eliminations of upfront commitments by cloud users and ability to pay for the use of computing resources on the short term basis as needed.	UC Berkeley [Armbrust, Fox, Griffith, Joseph, Katz, Konwinski, et al., 2009]
2.	Cloud computing embraces cyber-infrastructure, and builds on virtualization, distributed computing, grid computing, utility computing, networking, and Web and software services.	[Vouk, 2008]
3.	A type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service level agreements established through negotiation between the service provider and consumers.	[Buyya et al., 2009]
4.	A large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the infrastructure provider by means of customized SLAs.	[Vaquero, Rodero–Merino, Caceres, and Lindner, 2009]

Fig 2.1.1a Cloud Computing Definitions, Source: [Aldhawan, Nouf S., Ramzan, Muhammad S., 2022]

Cloud Computing is actually Internet-Based computing system in which different services like IaaS (Infrastructure as a Service), PaaS (Platform as a Service) and SaaS (Software as a Service) are available from remote computers. Cloud Service Providers provide those services from different Servers, Networks, Storage, other required hardware and software applications as required to the customers. [Urs, Holzle, 2012]. The most beautiful thing that Cloud Customers get services on pay per use basis so that they can hire the service as they require. The Cloud Computing Technology is easily configurable and services are available by the virtualization of the resources like servers, storage, high end hardware and latest version applications as required by the customer. The customer pays as per the use of the infrastructure provided by the Cloud Service Provider on demand of the Customer [Raghavendran et al., 2017].

The basic Cloud Architecture has Cloud Database Storage, Cloud Platform, Network, Cloud Virtual Resources and Application Software as in fig. below:

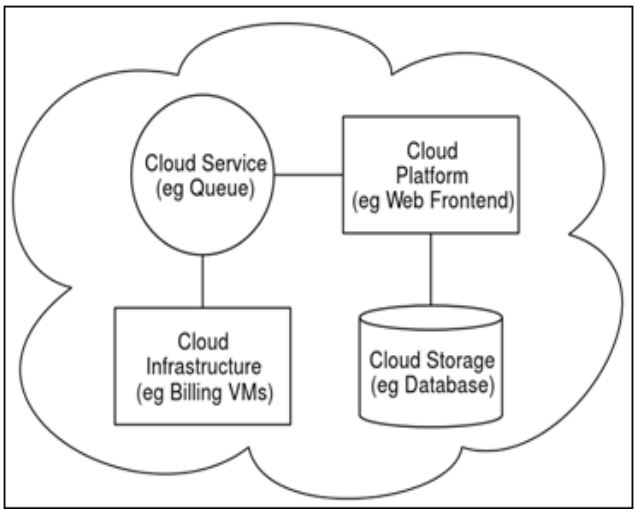

Figure 2.1.1b: Basic Cloud Architecture, Source: [Urs, Holzle, 2012]

Likewise, the Cloud Services have the three major layers IaaS, PaaS and SaaS. The fig. is as below:

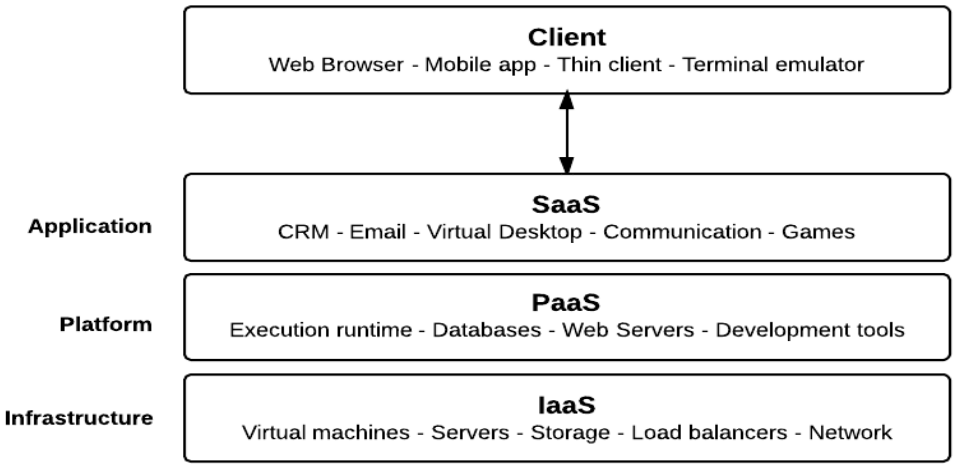

Figure 2.1.1C: Cloud Service Model, Source: [Urs, Holzle, 2012]

2.2 Use of Cloud Computing in Educational Institutions

Cloud Computing Service Providers provide several services like IaaS (Infrastructure as a Service), PaaS (Platform as a Service) and SaaS (Software as a Service) for educational purposes. Virtualization in Cloud Computing is another significant Cloud Computing facility which provides remote resources virtually in the local area. Also, it has security services to provide secured service to the clients all across the World (ALAMGEER & AHMAD, 2018). Many Academic Institutions in the US are adopting Cloud Computing for higher education's to improve the efficiency

of the educational system, to cut down the cost of education and to ensure the convenience in the academic sectors. The diagram of using different services of Cloud Computing for E-Learning is as given in the diagram below:

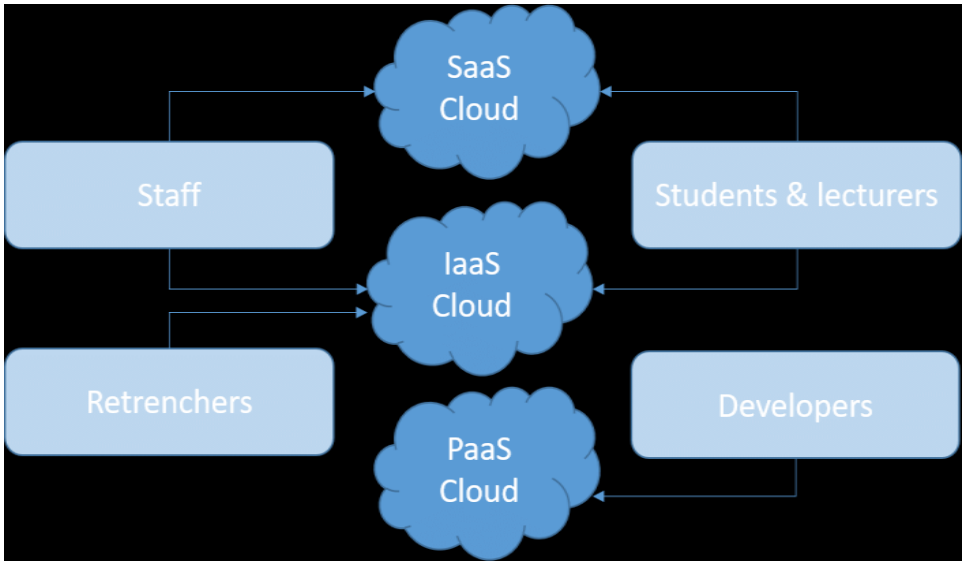

Figure 2.2.1a: Use of Cloud Computing Service in E-Learning, Source: (Almajalid, 2017)

The use of Cloud Computing is in the educational sectors like hosting LMS (Learning Management System) e. g. Moodle Blackboard within the cloud using by trainers and students, students use exam forms, learning courses, assignments online. Likewise, teachers use Cloud Computing in education for Course Management, evaluation of homework, assignments for students and so on (Almajalid, 2017). Academic Institutions can take advantage of adopting cloud computing in E-Learning in low budget. Those academic institutions who have no infrastructure and under budget can take advantages for effective E-Learning from Cloud Computing. They can provide E-Learning materials from E-Mail, Calendars, photo sharing, contact list document storage, creation and sharing of documents. Google is one of the biggest service providers that provides services like Google Apps, Google Maps, Google Forms, Gmail free for cost (ALAMGEER & AHMAD, 2018).

Development of ICT (Information Communication Technology) and Internet Technology has great impact in the education system as ubiquitous type and having no boundary of time, space, gender, nationality, cast and origin. Internet supporting technologies and delivers required knowledge and improve the learning performances called E-Learning. Common E-Learning elements like text, picture, images, animations, audio, videos etc. that have great impact in effective e-Learning. For E-Learning, technology requirements include Video Conferencing, high quality audio, video streaming, high data storage capacity, sufficient Internet Bandwidth (BW) and cross platform to run the required applications (Ri et al., 2016). Developed countries have already adopting Cloud Computing in E-Learning like Virginia Virtual Computing Lab, Al-Badi, Oman, Sharma, Gobindaluri & Al-Kharusi etc. They have adopted Cloud Computing in E-Learning in individual and Institutional level. Developed countries have easy access of resources, whereas developing countries have several problems to adopt Cloud Computing in E-Learning. Resource problems, resource quality problems, lack of Labs, lack of communication, payment issues, lack of electricity power supply and stability of electrical power, insufficient internet Bandwidth, lack of awareness of E-Learning, security and privacy issues are major problems in developing countries to adopt Cloud Computing in E-Learning (Odeh et al., 2017).

According to Kumar Das and Ara, Madinah International University (MEDIU) has adopted distance learning for higher education in collaborative method with cooperative learning. It provides infrastructure, platform and educational services directly and by cloud service providers and academic institutions. They use SOA (Service Oriented Architecture) for E-Learning proposes to the students. Other Institutions who are adopting Cloud Computing for E-Learning are Washington State University's School of Electrical Engineering and Computer Science, higher education institutions from UK, US and others (Kumar Das & Ara, 2014). Other Popular E-Learning Institutes using Cloud Computing Technologies are Virtual Learning Centers of Granda University, the Open University of California, MIT Open courseware, Free online course of Stanford University etc. (Patnaik and Putta, 2014).

The Cloud-Based E-Learning environment provides the facilities of Distance Learning (DE) with learner's involvement as in the given diagram below:

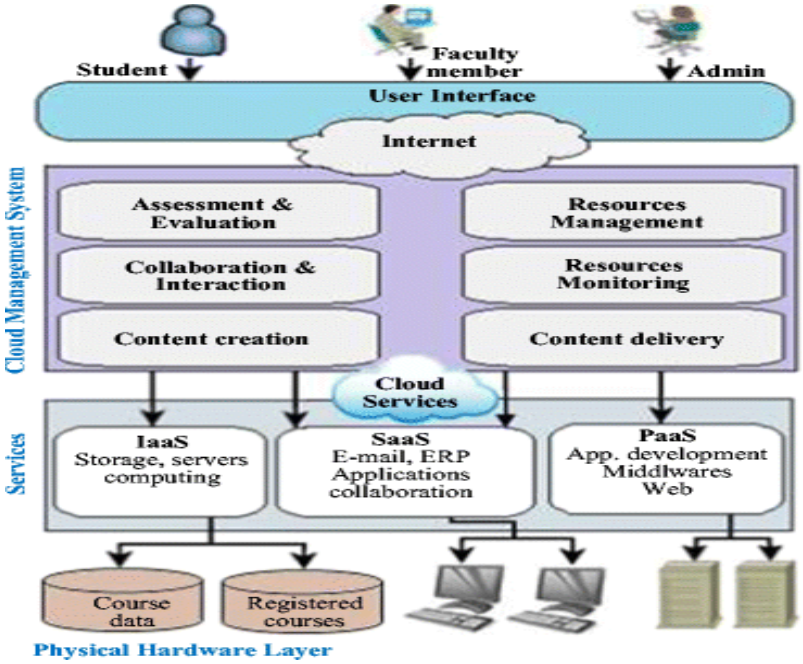

Figure 2.2.1c: Components of E-Learning System, Source: (El Mhouti et al., 2018).

2.3 Benefits of Cloud Computing in E-Learning

There are several advantages of using Cloud Computing for E-Learning. Due to this reason, cloud computing based e-Learning has been adopted all over the World. The advantages of using Cloud Computing in E-Learning include pay per use services, service access for 24/7, protection of environment using green technology, increasing functional capabilities and so on (Mtebe, 2013).

Likewise, Cloud Computing based e-Learning has advantages like service is economic, scalability, service availability and sustainability (Olanrewaju et al., 2017). Security, Privacy, easy to use and platform compatibility are also significant benefits of using Cloud Computing in E-Learning (Odeh et al., 2017).

The use of Cloud Computing in E-Learning also cuts down the cost of ICT investment in Educational Institutes, can be centralized the data storage required for the learning institutions, no license and user side software needed. Similarly, it provides virtualization facilities for resources, it has easy monitoring system to the activities of teaching learning, manages higher data security, high availability and has facilities of data backup and recovery (AI-Mhouti et al., 2018).

Other advantages of using Cloud Computing in E-Learning are high resources availability, super computing power, no data loss due to crash recovery, convenient to use, economic efficiency (ALAMGEER & AHMAD, 2018). Also, it has personal work space, various simultaneous operations, omnipresence of online applications, support of mobile learning, publishing and sharing calendars, documents, webpages, low infrastructures and tiny classroom problems can be addressed. It maintains the democratization in education delivery system and better educational quality can be managed (Almajalid, 2017).

2.4 Adoption of Cloud Computing for Teaching-Learning in different Asian Countries:

Asia is the biggest continent in the World with recently developing in Educational and Technical Fields. Along with this, E-Learning using Cloud Computing has been prevailing with great impact in Asian Countries. E-Learning was started quite a long ago. However, it became very popular during COVID-19 pandemic. The developing countries considered in this research work are Bangladesh, India and Pakistan whereas the developed country under consideration is US.

2.4.1 The Proposed Architecture and Framework of Cloud Computing for Bangladesh Education System:

Bangladesh has adopted E-Learning using Cloud Computing for Distance Education (DE). The government of Bangladesh has developed an architectural framework for E-Learning using Cloud Computing. According to Noor and Mustaq, Bangladesh Education System proposed an Architectural Framework using Cloud Computing. The proposed Cloud-Based Architecture consists of Cloud partners and local servers (Alkidi et al., 2014). The diagram is as below:

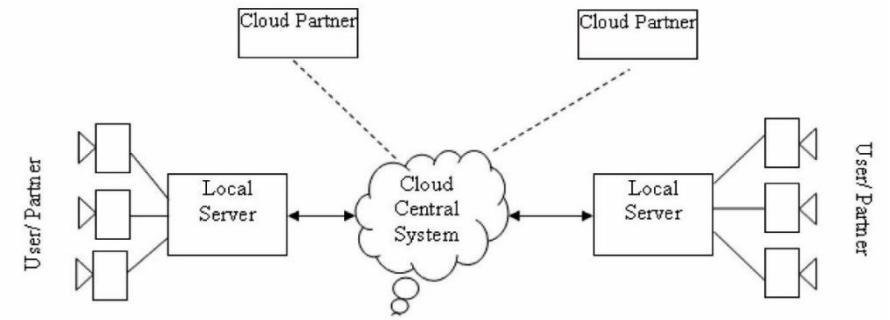

Figure 3.2.1b Cloud Computing Architecture for Bangladesh, Source: (Noor et al., 2010)

2.4.2 A Conceptual System Architecture for Cloud-Based E-Learning System for Education in India:

India has progressed significantly in the field of Information Technology in the recent years. In India, conceptual architecture of Cloud Computing for E-Learning purpose has been designed in three layers (Alkidi et al., 2014).

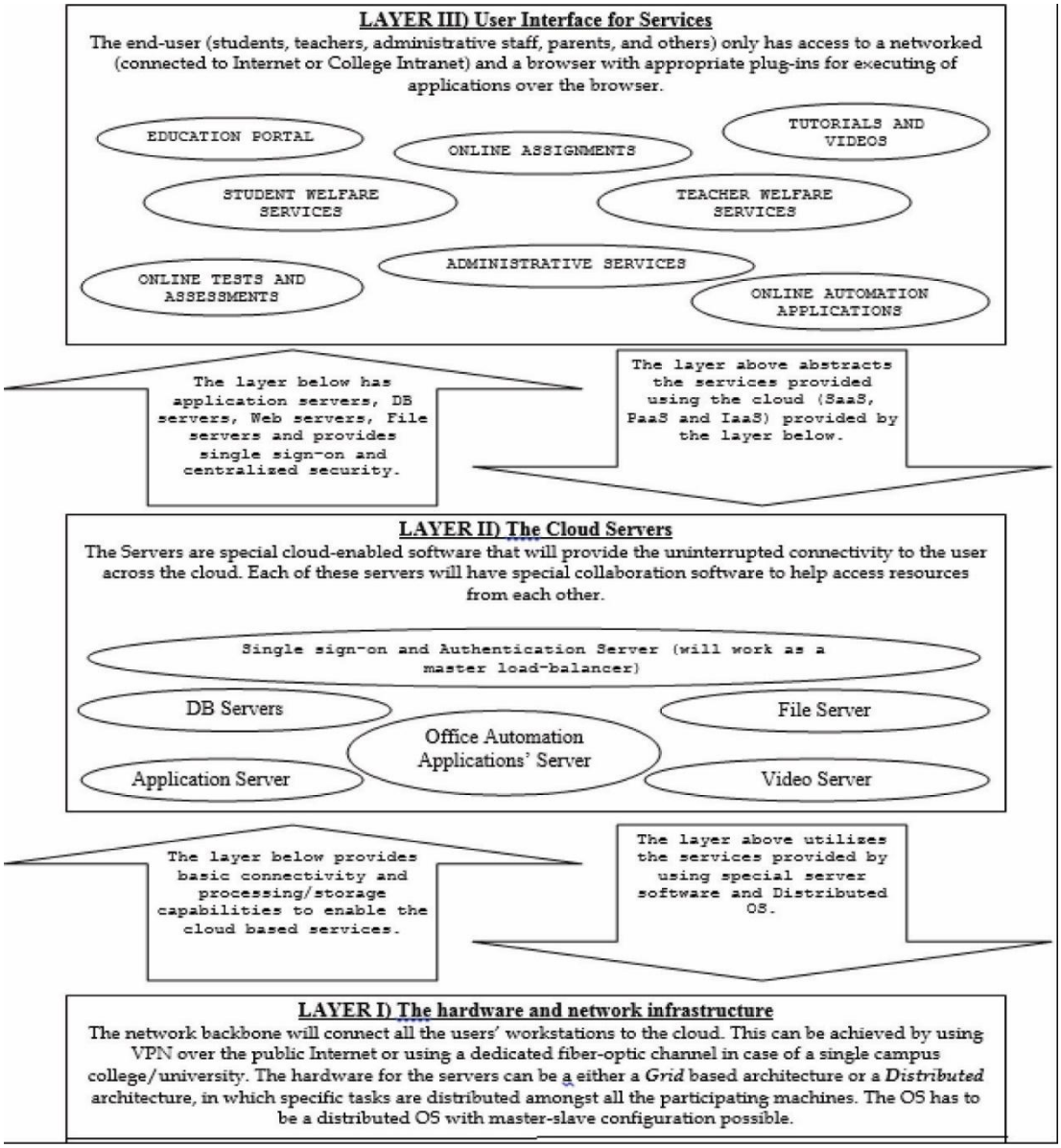

Figure 3.2.2: A model Architecture of a Cloud-Based E-learning System for India, Source: (Khetan & Gupta, 2013)

Each layer is described as below:

a) User Interface Layer:

This layer has the responsibility of video tutorials, lecture notes, educational portals, online tests and assessments.

b) Cloud Layer:

This layer consists of sign-on-authentication server, Web Server and Application Server. The responsibility of sign-on-authentication server is to verify whether the user is authorized or not. The Web Server has the responsibility to

deliver the learning elements that can be accessed via Internet. Application Server has responsibility to provide the environment for stake holders to execute their applications.

c) Hardware Layer:
This layer has responsibility to connect all the work-stations on the Cloud. Since this model uses both public and private clouds, so it is Hybrid Cloud Model for E-Learning purpose.

2.4.3 Hybrid Cloud for Educational Institutions in Pakistan:
Pakistan has adopted three-tier cloud architecture which has been used in Pakistan for E-Learning purposes by educational institutions. This model uses both private and public Cloud. So, this model is based on hybrid Cloud-based three-tier architecture (Alkidi et al., 2014). The following are the responsibilities of each tier:

a) Tier One:
This tier is responsible for authentication, Proxy and Data Storage. Eucalyptus Open source cloud computing is used in this architecture that provides a structure to manage the services.

b) Tier Two:
This Tier is Intermediate Model which facilitates to the developers to use scripting and programming languages including Web 2.0/3.0. It interconnects Public Cloud APIs, Google App Engine, Sun's Cloud API and Microsoft's Azure services. It uses Aneka Cloud platform which enables developers to run their own programming applications and to develop programs and applications on the cloud.

c) Tier Three:
This Tier of the architecture is responsible for virtualization and VM management. This architecture uses Open Nebula which is open source for supporting Virtual Machines (VMs) in Public and Private Cloud for the management of heterogeneous data center.

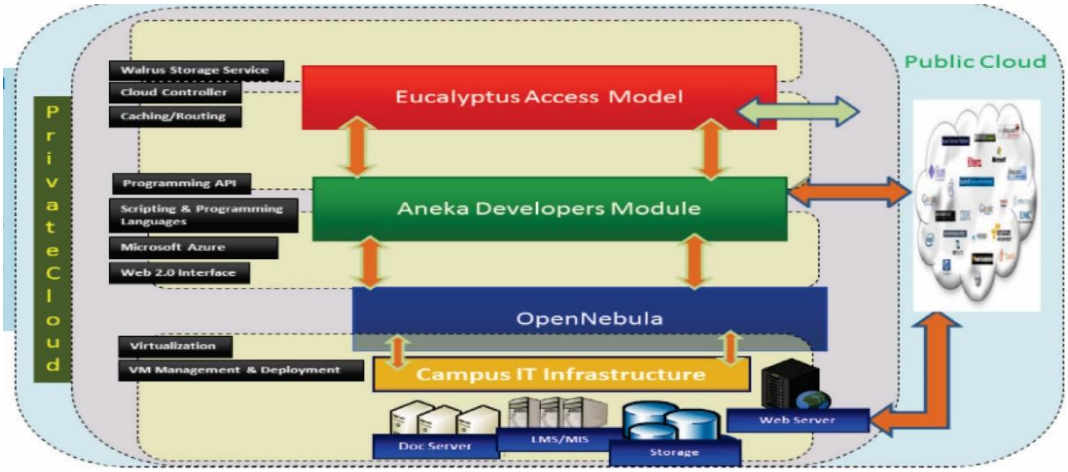

Figure 3.2.3: Hybrid Cloud Framework for Higher Educational Institutes in Pakistan, Source (Alkidi et al., 2014)

2.5 Adoption of Cloud Computing in Educational Institutions in the US

In the USA (United States of America), SOA (Service Oriented Architecture) of Cloud Computing has been used in different universities for Higher Level Education. The very popular Universities like University of California and Washington State University's School of Electrical Engineering and Computer Science are the examples of US universities that are using Cloud-Based E-Learning system. Likewise, Virginia Virtual Computing Lab, North Carolina State University are also using Cloud-Based E-Learning Distance Education in USA (Kumar, Das and Ara, 2014). The University of California (UC) is using AWS (Amazon Web Service) cloud infrastructure that acquires large number of Servers (Alkidi et al., 2014).

Apart from these Universities, other educational institutions like University of Carolina, MIT Open Courseware, Free online Course of Stanford University and so on (Patnaik & Putta, 2014). Medical College of Biotechnology Wisconsin is using Cloud infrastructure of Google Cloud Servers with high computing capacity for protein research (Alkidi et al., 2014).

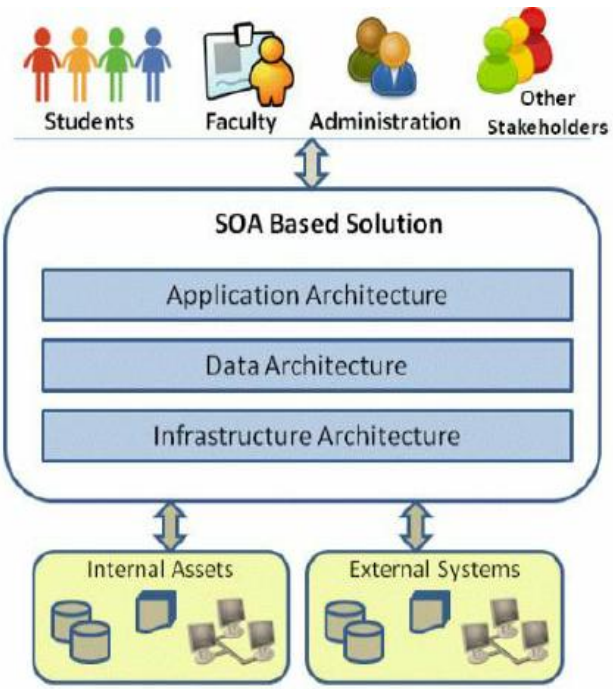

Figure 3.3: SOA-based E-Learning used in the US, Source: Alkidi et al.; 2014

3. Research Methodologies

The methodologies of this research include the design of the Cloud-Based E-Learning Framework and its Implementation. Another technological design is to transform physical classroom into virtual classroom to provide the quality education to the students who study in rural academic institutions. Also, it includes the technical design for those students who are in the rural area (semi urban areas) with limited internet BW and that area where there is no Internet service available (remote areas). For those students, alternative technology has been proposed using Ku Band Satellite. Ku Band Satellite has been proposed because of its affordable receiving system for academic Institutions and individual students.

3.1 Designing the Cloud-Based E-Learning Framework

Generally, the developing countries face lack of infrastructure and limitations of resources for Cloud Computing based E-Learning. However, the academic institutions in Nepal in urban area can manage Cloud-Based E-Learning system for Distance Learning (DE) purposes because of easy internet available. Students can access E-Learning materials from Cloud managed by their academic Institutions including all required services via Internet from their home. Like in Bangladesh, India and Pakistan, the author designs the Conceptual Framework Architecture for E-Learning with using Cloud Computing Technology. The Cloud Computing allows to use not only to teachers and students, but also to administrators, program developers and trainers as well using its different services like SaaS, PaaS and IaaS. The academic institutions use different software and applications without any issue of license for general teaching/learning purpose using SaaS, the program developers use different operating systems, database, web servers, Programming Platform using PaaS and researchers and designers use high speed CPU, RAM, Graphics Card and other hardware facilities using IaaS with the help of Cloud Virtualization (Alkindi et al., 2014). The Conceptual Layout for Cloud-based E-Learning for Distance Education (DE) in context of Nepal is as below:

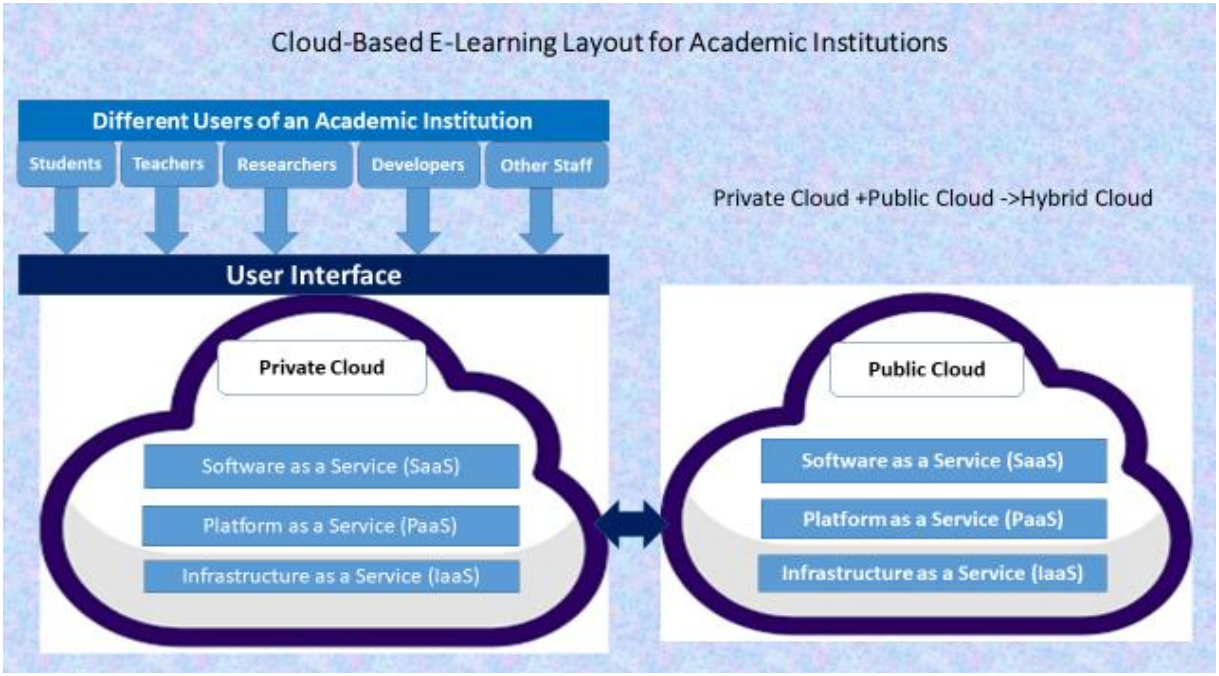

Figure 4.4.1a: Cloud-Based Layout for E-Learning System proposed for Nepal, Source: Author's Design

The conceptual framework architecture of the Hybrid Cloud-Based E-Learning is the design that the educational institutions need to get different services and facilities and methods of operation to the E-Learning System. The system is the Hybrid Cloud Computing environment so that the users can access the services from Private as well as Public Cloud environment. It includes the User Interface Layer where the users log in the system using authentication server, then the users access different services like SaaS, PaaS and IaaS from both Private and Public Cloud Computing environment.

The Conceptual Architectural Framework of Academic Institutions of Cloud-Based E-Learning System for Distance Learning is as below with the description of each Layer:

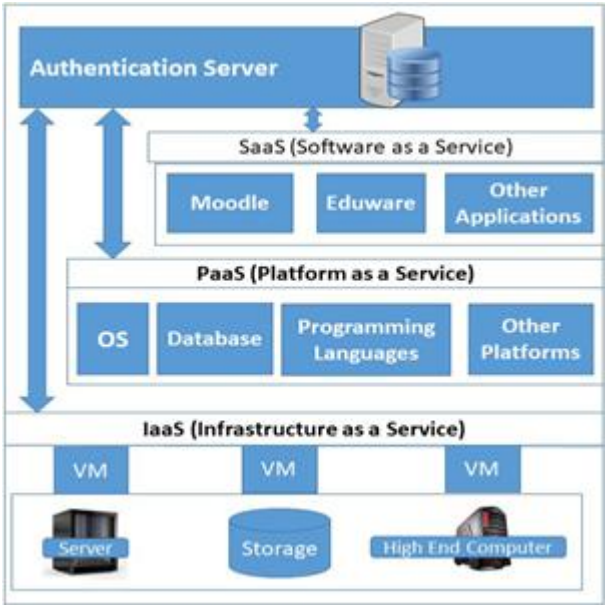

Figure 4.4.1b: Conceptual Framework for Cloud-Based E-Learning, Source: Author's Design

a) User Interface layer:

User Interface Layer is the Interface in between User and Cloud System. It contains the Authentication Server that authenticates the User. As soon as the User is authenticated, different required Cloud Services can be accessed in Private Cloud as well as Public Cloud as per the Service Level Agreement (SLA). The User needs username and strong password to access the Cloud which is authenticated by the Authenticated Server. After verification, the Authentication Server allows user to access the Cloud Services and contents.

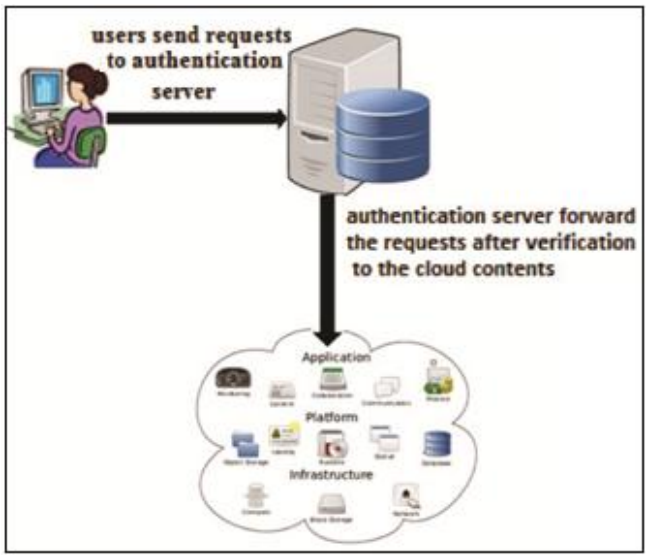

Figure 4.4.1c: Communication between user and Cloud for Authentication, Source: (Alkindi et al., 2014)

b) Software as a Service (SaaS) Layer

SaaS (Software as a Service) layer of the design provides services of application software for academic purposes and for other requirements. For academic purposes, it provides different MOODLEs (Modular Objective Oriented Dynamic Learning Environment), Eduware (Software Applications related to Education) and other required applications.

c) Platform as a Service (PaaS):

This service Layer of the design provides different required platform services for the Educational and other purposes. It provides services like different Operating Systems (OSs), Databases, different programming languages for program development and other required platforms.

d) Infrastructure as a Service (IaaS) Layer

The IaaS (Infrastructure as a Service) layer provides essential infrastructures required for the academic and other purposes. It provides Cloud services like different Servers, Networks, Storage, High End Computing Capacity and other required infrastructure services.

3.2 Technology Design to Transform Physical Class to Virtual Class

Those students in the remote areas who do not access of high quality classes can access the online virtual classes happening in city area from highly qualified and experienced teachers. Those students who cannot access the physical classes due to their job in the other cities or financial problems also can access the virtual class happening in another place physically. In context of Nepal, academic institutions cannot continue physical classes due to frequent political disturbances, natural disasters and pandemics. In this situation, the academic institutions can continue academic classes and trainings using this technology. The technical design to convert the physical class to virtual class is as the design below:

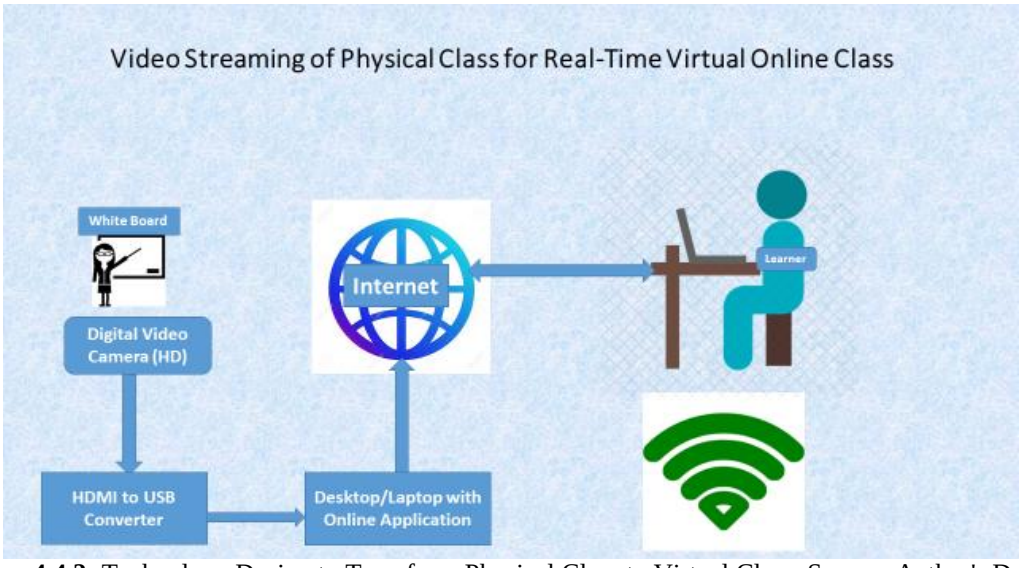

Figure 4.4.2: Technology Design to Transform Physical Class to Virtual Class, Source: Author's Design

3.3 Implementation of Conceptual Framework of Cloud-Based E-Learning System

The designed layout has been converted into technical design which is Hybrid Cloud-based E-Learning proposed Architecture for Academic Institutions and students of Nepal. The Hybrid Cloud Deployment model has been proposed to store and access both local and distant educational content. The Conceptual Architecture designed for E-Learning proposed for Academic Institutions and students have the following components as in given fig:

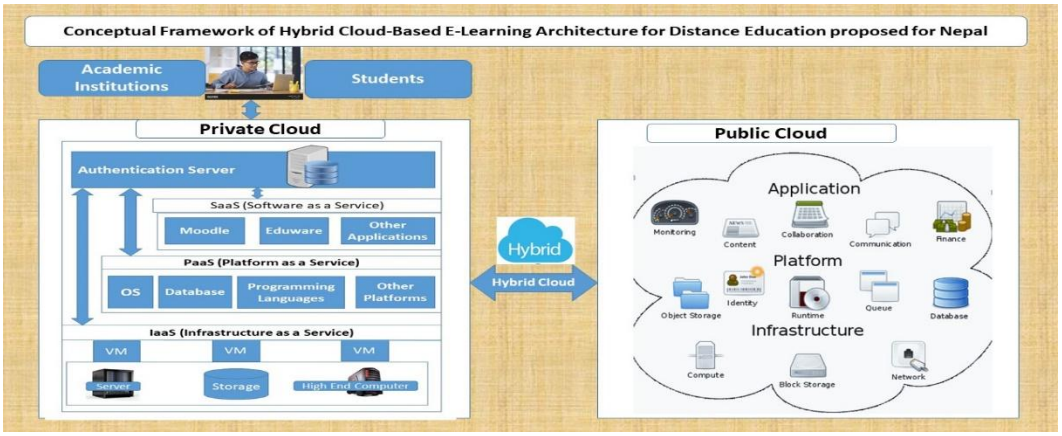

Figure 4.4.3: Design of Hybrid Cloud-based Architecture for E-Learning, Source: Authors Design

The academic Institutions and students can access the Cloud Service through Authentication Server in which authorized user ID and password are used. As soon as the Authentication server verifies or authenticates the user, the user can access for both private and public cloud for different services (Alkindi et al., 2014).

The Private Cloud is the Local Cloud service owned by the Institution itself or third party that provides all services SaaS, PaaS and IaaS. The academic Institutions use this type of Cloud for Library Management and security purposes. It is scalable and provides all required services for users using virtualization (Bai, 2014).

Public Cloud is the Cloud Service proved for public. This service is available for several users and Institutions. Google, Amazon, Microsoft's Azure, IBM Cloud and so on are Public Cloud examples. It sends same data, information and infrastructure for many users simultaneously. The same service is distributed in different locations and servers. So, if the service fails in one location, the other location provides the service (Bai, 2014).

3.4 Implementation of Physical Class to Virtual Class for Remote Students

The physical Classroom can be transformed for Virtual Class as well for the students who cannot attend the physical class due to their financial difficulties or due to their jobs in other cities or rural areas. Some students cannot afford to live in city area for quality education; however, they can access the city-based classes from this model of learning. The local academic institutions can manage real-time online classes of the academic Institutions of city for their students in the rural area. The technical requirements to transform physical class to virtual class are as below:

a) A Digital Video Camera (HD) with a tri-pod
b) HDMI Cable
c) HDMI to USB 3.0 Converter (Device)

d) A Laptop or Desktop Computer (At least I5 Processor) with Integrated Microphone and Speaker installed an OS and application Google Zoom or Meet or Microsoft's Team or Cisco's WebEx
e) High Speed Internet

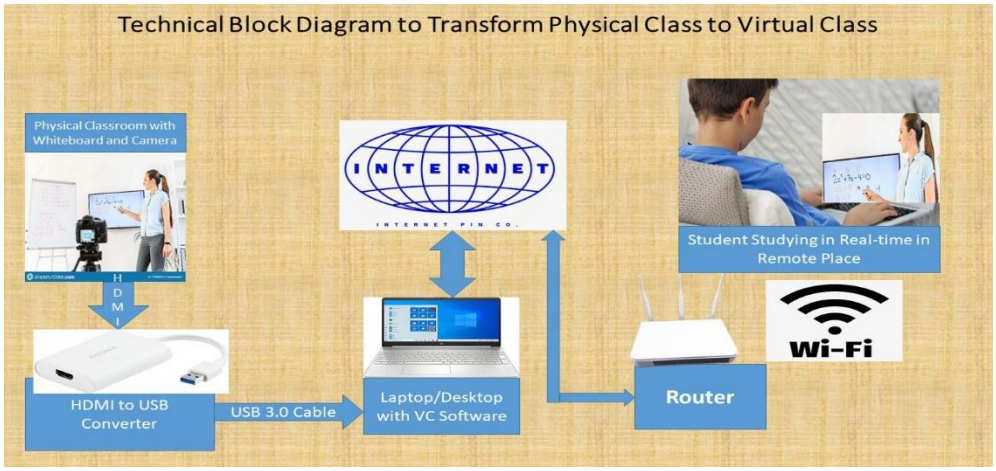

Figure 4.4.4: Transformation of Physical Class into Virtual Class, Source: Author's Design

3.5 BW Issue of Internet and Solution in E-Learning

To transform physical class held in the schools and colleges of city area to share to the students of remote schools and colleges, video streaming is carried out using the transmission medium as Internet. For the city area having enough Internet BW, there will be no issue for the smooth video streaming to the destination Institutions. However, the Internet BW in the remote and rural area of Nepal is not sufficient for the required quality of video streaming. In this research, author has given the alternatives of Internet as the audio/video transmission medium with using the Ku Band Geosynchronous Satellite to be received in the academic Institutions in Rural area. The students in village academic Institutions get the smooth virtual class on Television screen by down linking the Ku Band Satellite.

An Earth Station has to be setup for uplink the Educational Video for the remote students' purpose. The physical class held in any academic Institutions in the city area can be linked to the Earth Station with Optical Fiber Link. The educational video will be available in any location of the country. The academic Institutions located in the rural area can receive the educational video using a KU Band Satellite antenna and a set-top Box which has a minimal onetime cost. The educational video can be watched on a Television Screen in rural Institutions. The audio and video available from Satellite technology will be of one way. For the interaction of students and teachers, separate audio channel using VoIP system needs to be setup. The main use of this technology is to make smooth video available at the remote Institution in High Definition (HD) quality on large Television Set hanged on wall of a Class room. In this case, students in the rural area where sufficient Internet BW is not available will use Internet only for audio communication with teachers. However, the students who are in the remote area and there is no internet facilities at all will get the teaching activities via Satellite on TV screen and that will not be interactive with teacher.

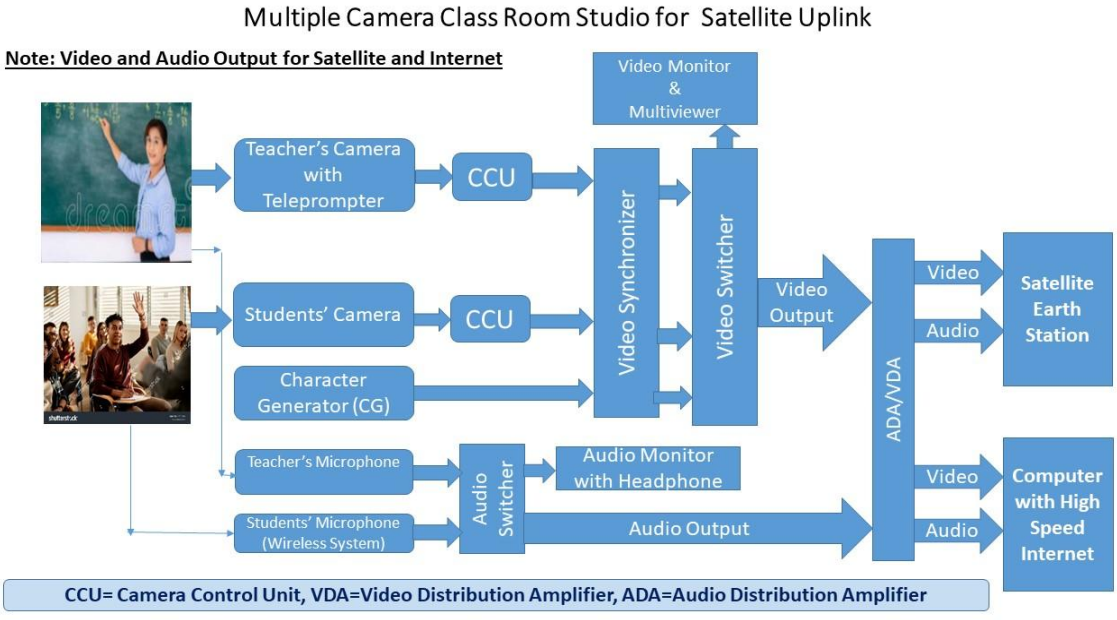

Figure4.6.2: a Multiple Camera Classroom Studio Technical Design

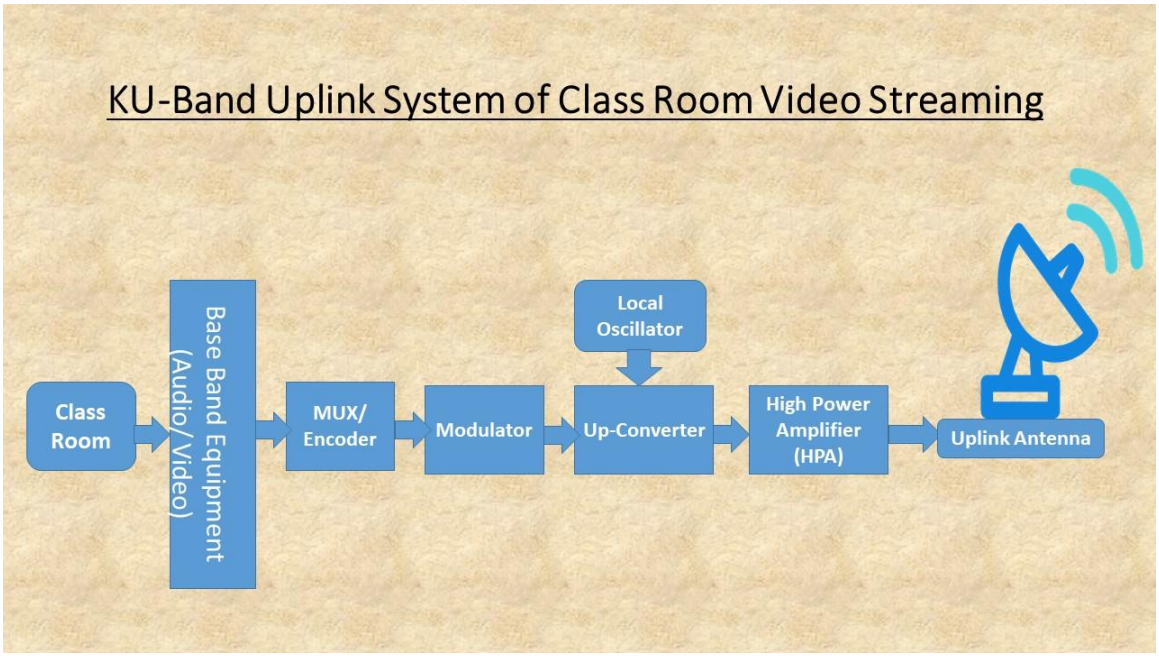

Figure 4.6.2b: Ku Band Uplink System of Class Room Video: Source: Author's Design

3.6.1 Video Channel Receiving System at Remote Academic Institutions:

The receiving system of the academic institutions in remote area is quite inexpensive and easy to receive. It needs just a receiving devices an antenna and a Satellite Receiver. The receiving antenna for Ku Band is too small of size of around 60 cm diameter in average. The other receiving device is a Satellite Receiver (set-top box). The video signal is encrypted so that only the authorized academic Institutions can receive the signal.

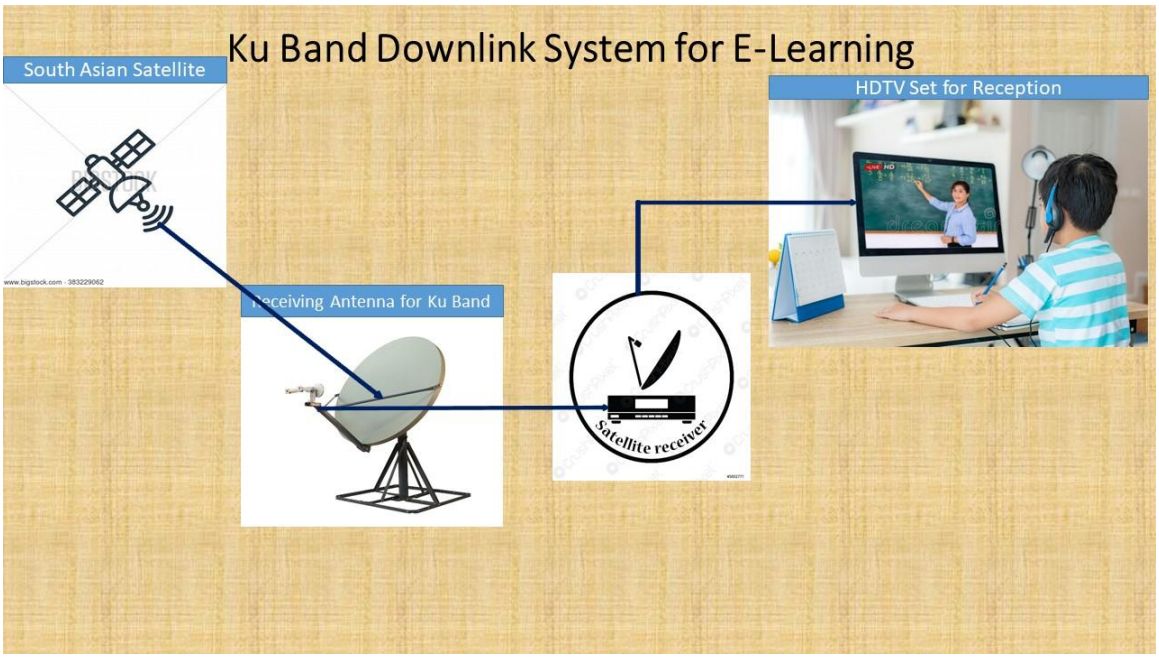

Fig.4.6.3: a KU Band Satellite Receiving System
Source: Author's Design

3.6.2 Audio Channel setup for Interaction between Teacher and Students

Since the audio/video transmission from the Earth Station is unidirectional so, that channel is not for the interaction between the teacher and students located in the remote schools and colleges. For the audio interaction, the Internet based channel can be setup. The audio channel consumes very less Internet BW, so the conventional Internet service available in the local area will be sufficient for audio channel only.

The technical design has been carried out for the audio interaction is as below:

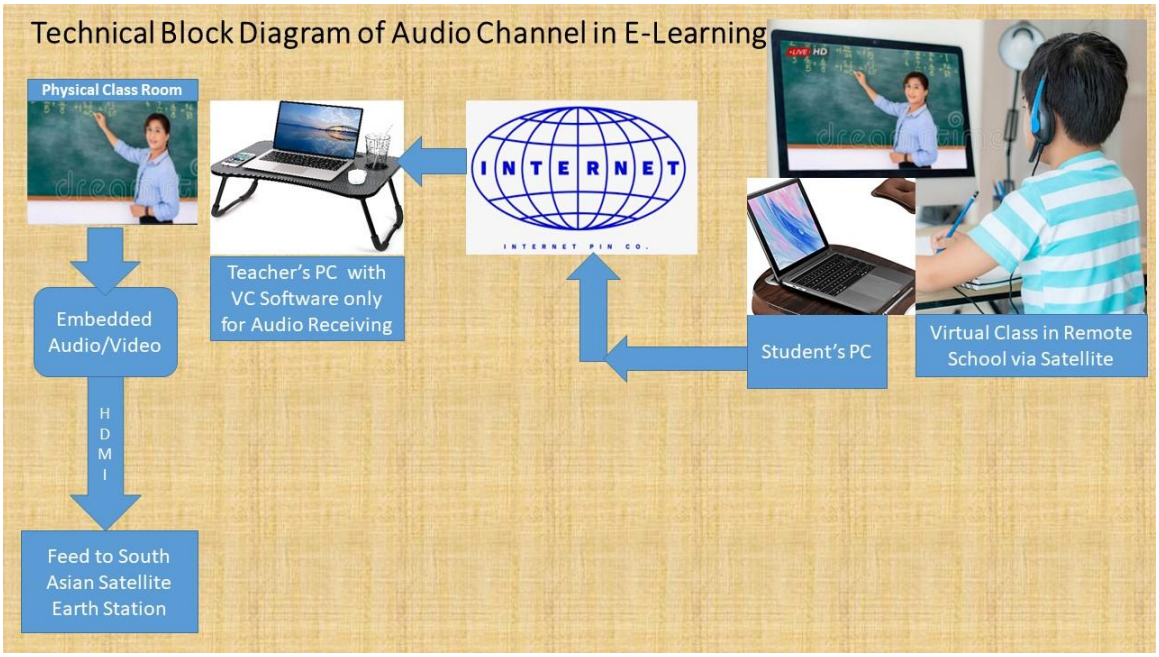

Figure 4.6.4: Audio Channel for students for interaction with teacher (Source: Author's Design)

4. Result

Hybrid Cloud Computing based E-Learning System is appropriate for all developing countries including Nepal for Distance Education (DE). The development of Information Technology (IT) has changed the academic activities all over the World. The Cloud-based E-Learning Model has no limitation of geographical boundary to learn and provides online education at anytime, anywhere and using desktop computers and mobile devices. Several required services are available for students, teachers, administrative staff, program developers and researchers can use this model of E-Learning.

For the rural academic Institutions, Ku Band Satellite System has been proposed to receive the real time class happening in the academic Institutions of the city area. The smooth video will be available for the students in the rural areas on High Definition (HD) Television Screen. The Class Room is setup for many students using wide screen Television set in the class room. The students may ask questions to the teacher using their VoIP audio channel over Internet. The teacher will respond from the mainstream satellite channel for all the students so that there won't be any audio synchronization issue or there will be no any lip-sync problem. For the remote area where Internet Service is not available, the non-interactive audio/video Class will be available on TV Screen from Ku Band Satellite Downlink.

5. Discussion

From the research, it is found that adopting Cloud-Based E-Learning by academic Institutions in developing country is very useful for the access of education for all and to maintain the standard quality of education as well. The research shows that using Cloud Computing for E-Learning in academic institutions is significant part of educational activities and important IT strategy. Several educational institutions in Nepal can use the Cloud-Based E-Learning Model for education to all and access of high quality education for the financially under-privileged people and opportunity to learn at the time of political disturbances, natural disaster and pandemic period like COVID-19. Transformation of physical class of city area into virtual class to access the students in rural areas who do not have access of quality education and cannot attend the classes due to financial difficulties and being busy due to their job in other cities and location will be highly benefited in Nepal.

Both Educational Institutions and individual students will be highly benefited from this model of E-Learning. Since, the model adopts hybrid Cloud which is the judicial combination of Private and Public Cloud that provides services for both students and other staff of the academic institutions as required. They can access the services from local private cloud and various other services from public cloud. It is also financially quite beneficial because payment is made in pay per use basis. The ministry of Education of Nepal needs to make policy, plan and implement this model to enhance the right of quality education of people.

Using this model in E-Learning, all levels of services will be available. Different computer application and software, Operating Systems (OSs), Databases, Programming languages and other platforms will be available for students, programmers, administrative staff and researchers. Other resources like servers, networks, storage and high end hardware resources also will be available using virtualization technique of Cloud Computing.

The alternative transmission medium used is Ku Band Satellite System for the rural area where Internet is too slow. The signal will be downloaded to receive in the classroom or and will be very effective to develop virtual class room using High Definition Television Screen of large size. The students will get the teaching activities of the teacher of the city area on big Television Screen. For the interaction with the teacher, they can use the VoIP audio channel over the internet. The teacher will answer the question using the mainstream satellite channel for both audio and video for all

the participating students. However, the students from very remote areas where internet facilities are not absolutely available will get one way teaching activities on Television screen by downlinking Ku Band Satellite.

6. Conclusion

From the overall research, adopting Cloud-Based E-Learning architecture is very useful for Nepal to access quality education for all over the country. The Ministry of Education of has to develop policy, plan, budget and implement the project for the quality education for all people. This model makes possible to spread quality education providing real-time physical class of city-based schools virtually to the rural schools at the same time. This policy will sort out the problem of differences in educational quality of the country.

Also, this research has provided the alternative method of using Ku Band Satellite System instead of using Internet as Transmission Medium which has BW issues for the rural and remote areas. So, this research provides the design to use Ku Band Satellite System for Teacher's audio/video transmission and using Internet for students' audio interaction with teacher in limited Internet BW areas especially in semi urban regions and non-interactive Class in remote areas on Television Screen. This will solve the issue of the limited Internet BW as well as the issue of audio video synchronization.

7. Recommendation

The proposed Conceptual Framework Architecture is the roadmap for the implementation for E-Learning for Distance Education (DE). This can be further enhanced in the future as below:

a) The proposed architecture can be implemented for all level of education system from primary school to Masters and Research Level.
b) This framework can also be used by different academic institutions to share teaching/learning materials and tools and can be further developed collaboration with different academic institutions.
c) In the future, academic institutions can reduce the number of physical classes and convert to virtual classes. That will reduce the cost of both academic institutions and students with the better quality of education.
d) Government may conduct teachers' training in large number at a time virtually using this model which reduces huge cost of training for thousands of teachers face-to-face.
e) Several open academic Institutions can be opened all over the country so that the educational quality will drastically improve.
f) The Ministry of Education can use satellite system for the teaching learning activities using E-Learning system to avoid the Internet BW issue in the remote areas.
g) When 5G-6G Networks prevail in the country, the E-Learning will be more effective to take class anywhere using any device.

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