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Cloud computing based E-learning

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Abstract
E-learning is related to distant-learning usually by internet. It requires to implement these large infrastructures are required by different organizations which is expensive. Cloud computing integrates web services like e-mail, web-applications, forums and learning platforms to use its infrastructure. It also supports data mining from which inherent knowledge can be extracted by accessing different databases. Cloud computing is viable solution to this problem. Its inexpensiveness is a boon for those organizations who often find it difficult to deploy, monitor and manage online laboratories known as virtual labs. It is an adoptable technology due to its adjustability and usage of virtual resources through internet. The paper will discuss challenges faced in development of e-learning systems and how cloud computing resolves these challenges. It will also discuss about the advantage of cost effectiveness of the technology for its implementation of hardware and software, the convolution in its implementation and how it can be reduced, its impacts on E-learning, and how current models lack the support of infrastructures for effective utilization of available resources and a sustainable approach towards e-learning.

Keywords: Cloud computing, E-learning, resources, service, ecosystem, model

1. Introduction
Education is one of the most important parts of someone's life as without it, survival without it is a difficult task to perform. There are multiple patterns or paradigms of receiving knowledge. One of the most famous of these is E-learning which is getting more and more famous these days, which uses resources based on Information and Communication Technology (ICT) for teaching and learning. There are many institutions which are not able to afford proper infrastructure to support E-learning which creates a backlog. Poor or insufficient technology leads to lack of education even if good teachers are available. Even if the prices of hardware and software are going down, there is a requirement of the staff that knows how to manage that technology. To solve these issues cloud computing is one of the most important paradigms that can be adopted by someone. It provides virtualized resources (network servers, applications operating systems, platforms infrastructure segment and services) and dynamic scalability at a very less price which can be accessed through internet at a very less price. Integration of E-learning with cloud computing has revolutionized cloud computing. It provides an effective infrastructure and fulfils the dynamic needs of various institutions. It has provided a solution to multiple problems like, flexibility, accessibility, security, privacy, cost reduction and quick and effective communication. Cloud computing moves the processing effort from local devices to data center-facilities. It can be accessed on multiple devices like mobile phone, personal computer, etc. Virtual laboratory is an important aspect of e-learning. E-learning supports distant learning in which these virtual labs play a vital role as for a person who wants to perform various practical experiments needs to have access to components of lab. A virtual machine, an operating system and the required application together contribute to from a virtual lab.
Cloud computing can also be referred as an E-Learning Ecosystem as it helps in building a sustainable architecture where its dynamic scalability helps in dealing with fault-tolerance and with bursts in demands of resources and its regular configuration and management help in utilization of resources at maximum levels. The online resources help a lot as none of the students and teacher need to install any kind of app on their systems as all the hardware, processing and storage files run on internet. These applications are stored in different servers and can be accessed from all over the world.
Overview of the paper: Section two discusses about the concept of E-learning, Section three discusses about the concept of cloud learning and even provides information about its service models and cloud models.

Section four discusses about the infrastructure required by the cloud computing ecosystem to develop a sustainable approach. Section five discusses about the implementation and management of virtual laboratories on cloud computing system. Section six provides some benefits of cloud computing system. Section seven provides drawback of using a cloud computing system. Section eight provides a conclusion of all the sections.

2. E-Learning

E-learning basically supports all forms of electronically based teaching and learning. The Information and Communication Technology (ICT) Systems serve as the basis in this learning process. Because of this technology students can learn even outside the classrooms and provides the studying environment in both of them. In this, the knowledge and skills are transferred through network-based applications where the processes include web and computer-based learning, virtual education and digital collaborations. These include various animation videos with different type of sound effects, texts and images which help in visualizing multiple process in these learning. E-learning is beneficial in three ways:

- **Time:** Many students often prefer to study at their preferred time of the day. These online classes help them to study whenever they wish to. They can even download recorded lectures and see them at their preferred time.
- **Location:** Through E-learning students living in remote parts of the country can access these resources with the help of an internet connection. They can attend live online classes, lectures and can even participate in different competitions, give exams and can even download study materials.
- **Communication:** E-learning allows students to communicate with their fellow students and with their teachers. These can be initialized through e-mails, forums, chat-rooms and thread discussions.

E-learning even helps these institutions in as these institutions as their investments improves because they have to pay only for fixed number of users, lesser costs for maintenance of their campuses like in electricity bills, water taxes and hard copies of study material as E-resources are shared with students and teachers. They get more students and teachers from different parts of the country because of which the productivity increases. So, E-learning is great way to enhance development of skills and performance. Although E-learning favors productivity but still there are some challenges. Deployment of these services require a proper E-Learning system which is expensive. When this education is provided to masses, an exponential growth is observed which requires dynamic scalability in allocation of resources and their effective utilization of available resources.

3. Cloud Computing

Cloud computing is a technology which enables its user to access different systems, applications and software through internet. These systems are not those which can be carried around like laptops or desktops but are maintained in large data centers. In recent trends the IT companies have shifted their data in these data centers which can be accessed at any location with the help of internet. These systems have improved the efficiency of computing devices buy centralizing data storage, processing and bandwidth.

It is a model which provides a convenient and shared access to dynamically scalable computing resources (storage servers, processing hardware like RAM, CPU) with very less management efforts and minimal interaction with service providers. Its users are allowed to virtually access these systems with the help of internet. They can configure the properties of the system which they want which can be virtually accessed through internet on any device. The definition of cloud computing as provided by Mell, Peter and Tim Grance to NIST (National Institute of Standards and Technology) is, “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”. This definition provided by NIST provides five characteristics of cloud computing. They are, On-demand self-service, broad network access, resources pooling and measured service. It also provides three service models and four deployment models. Cloud computing takes on a service driven business model which provides three service models.

3.1 Service Models

- Infrastructure as a service (IaaS): In this equipment like computing devices like CPU and memory and storage drives are provided in the form of service to clients which provides them the option to take it on lease rather than buying entire dedicated servers and other equipment. For example, amazon provides EC2 for computing power, S3 for storage purposes and SQS for network communication to small trading companies and individual clients.
- Software as a Service (SaaS): In this type of model, software applications are provided which can be accessed on the web rather than purchasing their offline packages as individual customers. For example, Salesforce.com provides services of CRM applications, office applications which are provided by Google and are completely web based like, word processors, spreadsheets, etc.
- Platform as a Service (PaaS): This model includes the support of complete application deployment lifecycle which includes design, implementation, debugging, testing and support multiple internet-based apps which include large number of characteristics from desktop apps entirely on internet. Mostly web browsers are used as deployment environments. For example, Microsoft Azure Services platform6, Google App Engine7, etc.

3.2 Models of Cloud

- Private Cloud: This type of cloud is provided by a single organization which could be comprised of many clients (e.g., trading units). The operation and management of the cloud be done by that organization itself, a third party or by them in a combined manner. They could even own the cloud. This cloud could be setup within the premises of that organization or may be off campus.
- Public Cloud: This cloud model consists of services like applications, storage facilities and other resources which are made publicly available to service provider.

These services could be free of cost or may follow pay-per-use model. For example, Amazon AWS, Microsoft and google own and manage this type of infrastructure which can be accessed only through internet.

- Community cloud: In this model the services are shared among various organizations which hold a common concern (security, compliance, jurisdiction, etc.). These can be managed and hosted internally by one of those organizations or by third party organizations. This has much lesser users than public cloud which reduces cost and helps in realizing the cost saving potential.
- Hybrid cloud: In this model a hybrid cloud is used which comprises of two or more clouds which can follow private, public or community cloud models. These remain eccentric to each other and are bound together which enables the user to get benefits of multiple models.

Figure 1 shows the cloud model which shows about the functions of clouds and how they work under the hybrid cloud

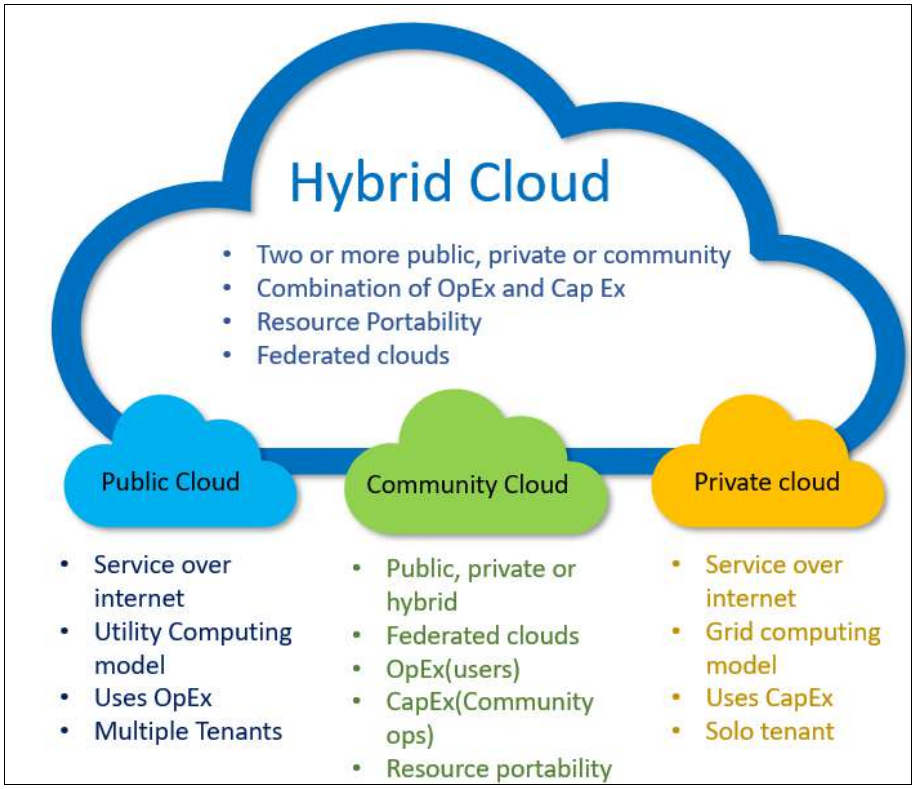

Fig 1: Cloud Model

4. Cloud Computing Infrastructure for an E-Learning Ecosystem

4.1 Architecture

According to, Uden, L., Wangsa, I. T., & Damiani, E, a cloud-computing infrastructure for an E-learning Ecosystem comprises of three layers and four modules:

- **Infrastructure Layer:** This layer is known as the resource pool of an E-learning ecosystem. A cloud computing platform manages this infrastructure. Virtualization technologies help in ensuring reliability and stability of the framework. It is also known as the Energy resource of an Ecosystem as it supplies resource like computation and storage services to other layers.
- **Content layer:** This layer stores of the E-learning study material and is comprised of web file systems, databases, web services, etc. Other than storing and maintaining content this layer also provides standard levels of connection and APIs of contents for higher layers.
- **Application Layer:** This layer provides E-learning systems, services, tools, etc. Function and interaction interfaces are also provided by this layer to user and other programs.
- **Monitoring module:** This module is responsible for keeping record of the execution of requirement demands, information which consists of real-time modifications and configurations and resource utilization levels of species which includes CPU health, I/O, memory, etc. These characteristics are used in maintaining a balance in cloud.
- **Policy Module:** This module is responsible for establishment and maintenance of run-time and resource scheduling strategies, teaching and learning strategies. It analyzes the facts received from monitoring module and the methods or strategies from the module itself to establish some particular solutions and later triggers provision module. It also determines the priority order of some species on resource scheduling. This prioritization depends on a bunch of e-learning policies that are used in the protection of the functioning of critical businesses.
- **Arbitration Module:** In this module some policies are manually created by authority in order to fulfil the demands of users and settle some disputes among species of E-learning ecosystem. It restores, modifies and enhances the management and allocation of resources. It takes into account the methods of learning, learning preferences and theoretical levels to establish

usage modes for different users. The policy defined in this module is given a higher preference over those in policy module.

- **Provision module:** This module is used for execution purposes. At first, the solutions for resource allocations that are set by the two modules i.e., policy module and arbitration module are executed and they later deploy the resources as per the demand from clients or species within a short period of time. This process is done automatically. Whenever it receives some request from user, it passes some data like user name, password and IP will be provided. Figure 2 shows that how different modules can be used in an architecture to manage different layers of cloud computing infrastructure.

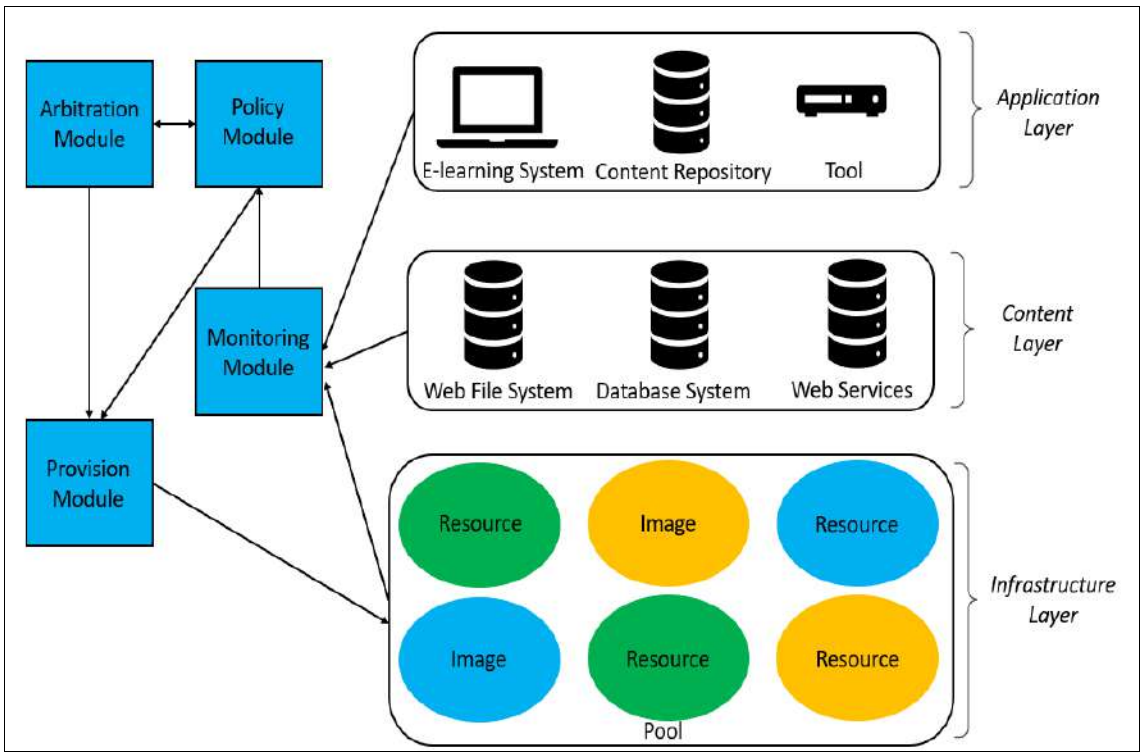

Fig 2: Architecture of an e-learning ecosystem based on Cloud computing infrastructure

4.2 Mechanisms

There are four mechanisms which are used for proper functioning of an ecosystem based on e-learning:

- **Pre-scheduling mechanism:** To access content in e-learning there are some rules which have to be followed like 80% access have their focus on only 20% contents and applications that are based on e-learning. An increase in requests is observed near exams, etc. so after analyzing these rules, policy module pre-schedules resources, contents and applications before the peak in access is achieved in order to safeguard performance in concurrent access. It helps in reducing resource redundancy and I/O costs thus increases quality of services.
- **Early warning mechanism:** Pre-scheduling mechanism is beneficial but it could degrade the health of other species which could result in longer average response time (from monitoring module). When monitoring data reaches its maximum capacity, it will be regarded as crisis. It will then find out some solution which will be later triggered to provision module so that it will assign some resources which might be idle or may belong to some other species. This will help to reduce the crisis. This even helps in handling other resources whenever burst in demands is observed.
- **Self-recovering mechanism:** An e-learning ecosystem's infrastructure comprises of large quantities of gadgets and other equipment which need maintenance. If any machine fails, it would lead to degradation of services provided by cloud computing. In self-recovering these faulty machines are detected with the help of monitoring module and candidate resources are generated for those species which have high priority.
- **Evolutionary mechanism:** This mechanism is responsible for progress or destruction of species to ensure absolute utilization of available resources. The utilization of services by a user to different species are recorded with the help of monitoring module. If the visit is lower, less resources are allocated to it. But, when the consumption of that specie reaches the minimum threshold level, the policy module asks arbitration module to take all the support from that specie thus make it extinct. This helps in ensuring the quality and sustainable use of available resources.

5. Virtual Laboratories Cloud System (VLCS)

An academic environment needs a laboratory which can come under E-learning through VLCS. It creates an interface among course MS or e-learning system and cloud MS. Moodle [10] is an example of VLCS. A new layer is created for generation and management of these virtual laboratories. For virtual laboratories, a system for the management of cloud is necessary but it also requires a course management system for proper utilization of available resources.

5.1 Objectives of VLCS

The primary aim of these services is the effective use of these resources of a private cloud at maximum levels. This can be achieved by keeping the resources under efficient supervision and scheduling of resources. The next objective of these services is the development of new methods in teaching that support more progressive learning and modules without being concerned about increase in complexity of VLCS, especially in the tasks that are concerned with management of cloud networks.

The third objective of these services is to work on Course MS and Cloud MS at the highest possible levels. At initial stages of development, these VLCS services will offer assist only for Cloud MS Microsoft System Centre 2012, VMware vCenter and IBM TSAM. Only supports of Moodle will be provided to Cloud MS or an e-learning system through a committed plugin.

5.2 Virtual Laboratory as a Service

VLCS provides the experience of final product or education aspect to virtual lab services. Because of this, the notion of Virtual Laboratories as a Service (VLaaS) has been introduced by VLCS the scope of IaaS has been increased due to VLaaS as it adds new services and more functionality in it. These final product services, functionalities and cloud resources could be provided under VLaaS but could come only under the conditions of a course or a laboratory.

5.3 Virtual Laboratories Management

The core or primary unit of a VLCS is a virtual laboratory that comprises of hardware and software resources. These resources could be hosted in a cloud-based domain that follow private, public or hybrid cloud model. VLCS provides some predefined framework to support management of virtual laboratories like, it uses some virtual machine templates to manage virtual labs or some virtual hardware and software to create a custom virtual laboratory based on request from user. The most prolonged task in this is the creation of these custom virtual machine templates. According to Beloglazoy, the creation of these templates requires customization in virtual machines (hardware resources), installing the OS, the tools that support the running of virtual machines like hypervisor tools or drivers, antivirus software and other support files like some study material (Lab manuals).

The configurations that are made to a virtual machine are based on user demand may not use custom virtual machine templates as the resources. It the resources that are required in its creation, the administrator might approve them. This approval could be done either manually or automatically. The users can choose from multiple services like Number of CPUs, number of cores per processor, memory size, storage facilities and networking capabilities. When it comes to software resources, the use could choose from available options which may contain list of compatible OS and additional applications which may be required to be installed on a virtual machine.

The most suitable way for configuration of these virtual laboratories is usage of predefined virtual machine templates. These templates are prepared much before creation of virtual machine. These have been tested and help in faster running of virtual laboratories. Though these templates provide a lot of advantages but it also has some disadvantages like, creation and testing of these templates is a more time-consuming activity, each and every step in its designing has to be carefully planned as it might raise compatibility errors, these templates are less flexible so rapid configuration changes are not possible on user requests.

The configuration of custom virtual labs provides flexibility but they also create a large number of problems like the usage of planned resources. These resources have to be made available on user requests and have to be configured to meet the demands of user and have some preconfigured components like compatible OS, applications and hardware resources.

5.4 Resource allocation and scheduling

For the management of user access and other permissions, Role-Based Access Control (RBAC) is used in VLCS. The functions that are defined by it in VLCS are liberated from the cyber safety systems used in systems responsible for management of cloud (Cloud MS) or those systems which are responsible for management of Course (Course MS). The roles defined by VLCS are: Manager, Environment administrator, content generator, content consumer. These roles can be provided with further extension if needed.

The request sent by user for allocation of resources contains a lot of information like, information about user who will serve as admin, hardware and software requirements, course for which these assets are demanded, time schedule for availability of cloud resources. Before allocation of resources the requests are needed to be approved by VLCS administrator. After this, the Environment Administrator grants these assets at most for course level. Content generator (teacher) later allocates assets for laboratories and content consumers (students). An example could be like this, A content generator can put forward a request for allocation 30 virtual machines with identical configuration. When these resources will be granted, 29 of them will be for students while, the last one will be configured as licensing server for the other 29. The lifecycle of a virtual laboratory comprises of the following:

- **Allocation of cloud resources to a course:** for this, the request for allocation of resources is made by a content generator and it can Environment administrator confirm that request.
- **Defining a Virtual Laboratory:** this step shows that resources can be shared at cloud level which could enable multiple laboratories work under the same course. Content generator is responsible for execution of this step.
- **Allocation of Cloud resource to virtual laboratory:** this step defines the resources which will be available to existing virtual laboratories. Content generator is responsible for execution of this step.
- **Allocation of users to virtual laboratory:** in this step users (content consumers) are added to the existing virtual laboratory which can use this laboratory. This step also defines user permissions. Content generator is responsible for execution of this step.
- **Configuration of the virtual lab:** in this step, configuration of virtual machines, virtual network configuration and schedule of usage of these services are defined by content generator.
- **Publishing or activating the virtual lab:** once the laboratory has been published, the content generator starts reserving the resources which is based on the

desired time schedule.

- **Hiding or deactivating the virtual laboratory:** When the management of cloud resources takes place, VLCS does not consider the resources and schedules of those laboratories that are either paused or might be in inactive state. Content generator is responsible for execution of this step.
- **Save the Virtual Laboratory Configuration:** this step is executed to recreate or restore a virtual laboratory. Information like name, description, users, resources allocated, virtual machine configuration, time schedule and usage history could be present in it. Content generator is responsible for execution of this step.
- **Removing users from the laboratory:** In this step the users of a virtual laboratory are removed. VLCS content generator can do this step either manually or automatically.
- **Release the cloud resources allocated initially to the virtual laboratory:** In this step the cloud resources are allocated to a virtual laboratory which can be done either manually or automatically by VLCS Content Generator.
- **Delete the virtual laboratory:** In this step VLCS Content Generator deletes the virtual laboratory.
- **Release the cloud resources allocated to the course:** In this step the resources that are provided to the virtual laboratory are deleted or partially removed if the virtual laboratories under that course have been deleted. This step could be performed manually or automatically by VLCS Content Generator.

Figure 3 shows a flow diagram of all the processes involved in the lifecycle of a virtual laboratory.

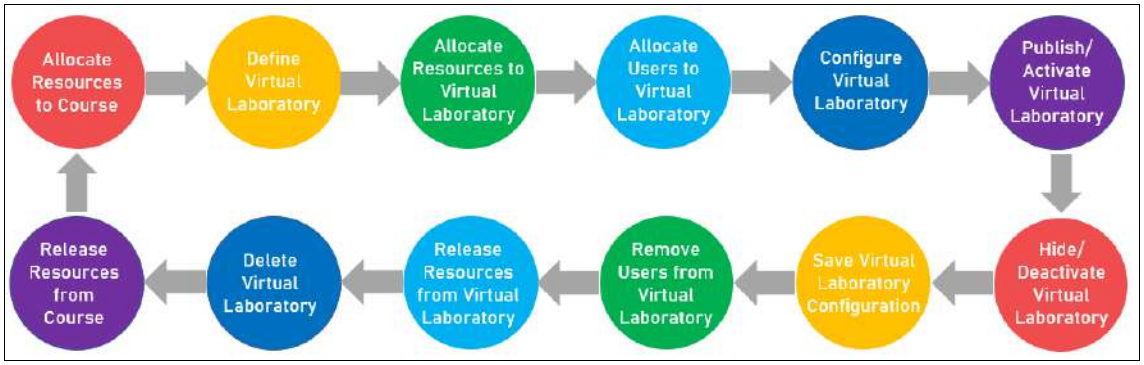

Fig 3: Virtual Laboratory Lifecycle

For scheduling the use of resources, the VLCS have the following framework: one or more virtual machines are provided to a single user (desktop) or multiple users (pooled desktop), where the scheduled usage time could be continuous or might for limited time. This limited time refers to the schedule in which these virtual machines could be used.

6. Benefits of using cloud computing for E-learning

- It can help us access and run multiple applications in cloud
- The software required to access cloud is either free or supports pay-per-use service.
- The cloud can be accessed at any time of the day.
- It can be used for data mining by keeping it open for researchers and business surroundings.
- It is environment friendly thus a green technology.
- It can help in the growth of functional capabilities.
- Since most of the applications are in cloud, the performance is not disturbed even if there is a problem in client's machine.
- Since the apps are in clouds, they are updated as soon as the updates are released so user always gets updated version of apps.
- Students get a lot of advantages as, they can attend online classes, join online courses, give online exams, send assignments to their teachers and even communicate with their instructors.
- Teachers even get advantages as they can teach in online classes, conduct exams, provide study material to their students, collect assignments and projects from their students, and interact with them using different forums.
- Data security is ensured using cloud computing as data is kept protected and a copy of it is kept safe at other data center so if any data center crashes (maybe due to server error, hardware fault or natural calamity), the user can get access the copy of that data which is kept safe at other data center. It is even protected from cyber-attacks [22-45].

7. Limitations of using cloud computing for E-Learning

- All the applications cannot run on cloud.
- Even after having multiple methods to access these services, they still do not have an organized support.
- Although these services can be accessed at any point of time of the day, but dispersion of policies can be a problem.
- Being open for data mining can lead to security problems and issues for sensitive data.
- It is an environment friendly technology but its solutions are not yet completed.
- Though it can help in increasing productivity but if some of its standards reach 100% utilization, it can create a problem.

8. Conclusion

E-learning is an efficient step towards providing knowledge to those who live in different parts of the world. Cloud computing is an efficient step towards making these services available at feasible rates and how it can increase productivity. This paper also discusses about service models and cloud models in cloud computing. It tells us about the infrastructure required for developing a sustainable

approach for E-learning thus developing an E-learning ecosystem.

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