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A Proposed Architectural Framework for Resolving Some Issues in Autonomous Cloud Environment

Tanmaya Kumar Das[1], Sasmita Mishra[2], Hari Narayan Pratihari[3]
[1]*Ph.D Scholar, Dept. of Computer Science Engineering & Applications, Indira Gandhi Institute of Technology, Odisha, India.*
[2]*Professor,, Dept. of CSE & Application, Indira Gandhi Institute of Technology, Odisha, India.*
3Professor,Dept. of Electronics & Communication Engineering,St. Martin's Engineering College, Dhulapally, Secunderabad, Telangana, India.

Abstract: *Cloud computing will continue to expand and dominate users' information transactions because it provides numerous benefits, including easy quick and individualized access to tools and information they require, wherever they are, and from any networked device. A great deal of cloud computing research has been concerned over some obstacles and challenges that rely upon behind the lure of cloud computing. Cloud infrastructure serves as a platform that offers the networking, storage, and processing power required to support a variety applications. Cloud computing users are expecting the quality of service that means the service providers are entitled to prevent even a failure on a single point. Cloud providers preferably maintain network infrastructure, storage facilities, and application software that promote reliability, performance, and usability. Because cloud computing is such an active environment, consistency of service may be highly alert, particularly to avail services as per the requirements of the users, changes in geographic locations and even during the days of natural disaster where the communication facilities like availability of internet is a great concern at the user end. This paper proposes a designing and implementation view with respect to an evolutionary frame work in order to deal with some of the encountered issues in autonomous cloud environment through a case study on e-learning aspect.*

Keywords: *E-Learning, Cloud computing, Autonomous cloud, edge computing, Adhoc-network.*

I. Introduction

Cloud computing has become a game-changing technology in recent years, transforming the computing industry and radically changing the way applications are created and accessible online. This paradigm shift involves delivering services via the Internet, allowing users to access hardware and software resources on-demand, paying only for the usage. Clouds can be a conglomeration of both physical and virtualized resources in centralized distributed data centers, supporting various workloads such as batch-style backend jobs and client-facing applications[04]. The adoption of cloud computing has significantly reduced the burden of IT infrastructure maintenance and management, offering economic and scalable solutions that benefit enterprises. Cloud environments require minimal software and hardware infrastructure, providing a convenient and efficient platform for various applications. In this context, e-learning, an internet-based learning system, has gained considerable attention from software developers and vendors due to the advantages offered by cloud computing[04].

Increasing the effectiveness, scalability, and flexibility of IT resources while lowering expenses and complexity are the main goals of cloud computing. Organizations can take advantage of pay-as-you-go pricing structures, flexibly scale up or down according to their needs, and access computing resources on-demand by utilizing cloud services. It enables businesses to focus on their core competencies, innovate more rapidly, and respond quickly to changing market demands without significant upfront investments in hardware and infrastructure. Cloud computing also facilitates in fostering innovation, enhancing collaboration, enabling disaster recovery, promoting sustainability, security, facilitating automation etc[04].

E-learning has a significant impact on the teaching and learning environment, utilizing a variety of media activities such as text, images, audio, and animation to increase student involvement. Establishing an effective e-learning system typically demands substantial hardware and software resources, necessitating significant investments. As education is an indispensable aspect of modern life, e-learning stands out as a crucial method, utilizing networked information and communication technology (ICT) for teaching, training, and learning. The components of e-learning encompass various formats, online learner communities, and content experts and developers. To keep pace with the evolving landscape of e-learning, incorporating the latest multimedia and communication technology is essential. Cloud computing emerges as an optimal solution in

this context, addressing challenges and providing a robust framework for enhancing e-learning systems. For academic organizations and institutions with limited budgets for hosting and operating online learning systems, cloud computing proves to be an excellent alternative. [02].

The widespread adoption of the internet and digital communication networks, together with the practice of distant education, as contributed significantly to E-Learning's growth. It effectively supplements classroom instruction by utilizing a variety of formats and resources. These include virtual instruction, email correspondence, web links, discussion boards, and diverse learning platforms. The integration of students, content creators, and professionals online has significantly enhanced the learning experience. Utilizing web-based tools offers numerous advantages, notably consistency, adaptability, accessibility, and ease of access[11]. E-learning or virtual teaching platforms are becoming increasingly popular in information technology (IT), particularly after the outbreak of Covid-19 and digital advancement. Various educational levels have embraced initiatives like Massive Open Online Courses (MOOCs), Blackboard, Desire2 Learn (D2L), and Virtual Learning Centers in universities, all adopting the E-Learning format globally. In contrast to traditional in-person classes, fully endorsed virtual programs offer an optimal learning environment, with a significantly increased accessibility for online learners. [01].

However, meeting the needs of a large number of online learners necessitates a strong infrastructure capable of handling variable demands quickly and dynamically. Cloud computing emerges as a feasible answer to these issues. Initially conceived to reduce computational costs while enhancing system reliability and availability, cloud computing has evolved to offer scalability, flexibility, and security for various applications. Unlike conventional computing grids primarily focusing on maximizing system performance, cloud computing prioritizes transparent mobility and diverse service provisioning, including hosting services and word processing[02].

One of the fundamental ideas of cloud computing is Service-Oriented Architecture (SOA), which seeks to overcome organizational computing hurdles such as application integration, concurrency control, and security protocols. Cloud platforms abstract the underlying technical complexities, providing users access to a wide array of services without needing detailed knowledge of the infrastructure. In comparison to the traditional setups, cloud computing offers evident advantages, enabling users to access applications without hefty investments in hardware[12]. This flexibility in resource allocation allows businesses to streamline their operations and respond dynamically to fluctuating demands.

As educational institutions worldwide increasingly adopt blended learning or fully E-Learning models due to the Covid-19 pandemic, ensuring secure and adequate resources remains a significant challenge[18].

This paper proposes a designing and implementation view with respect to an evolutionary frame work in order to deal with some of the encountered issues in autonomous cloud environment taking a case study on e-learning aspect.

II. Literature Review

2.1 Cloud Computing

Cloud computing has evolved as a breakthrough computing model, allowing users to access apps from anywhere utilizing connected devices. Based on concepts like grid computing, utility computing, and software as a service (SaaS), this model facilitates seamless access to applications with a user-centric interface that renders the underlying cloud infrastructure transparent[16].

Massively scalable data centers, where computational resources are constantly provisioned and shared to produce notable economies of scale, are the operational heart of cloud computing. The associated service management platform aids in cost reduction when adding IT resources, distinguishing itself from traditional infrastructures. Various players in the IT industry have introduced cloud computing initiatives, attracting heightened interest from corporate clients seeking services such as infrastructure outsourcing, software as a service, key processes as a service, and next-generation distributed computing. Cloud computing also functions as both a business delivery model and an infrastructure management methodology[14]. The business delivery model optimizes the use of hardware, software, and network resources to deliver innovative services over the web. Simultaneously, the infrastructure management methodology enables IT organizations to efficiently oversee highly virtualized resources, allowing a substantial increase in data center capabilities without a corresponding surge in human resources[11].

Cloud computing makes it possible to use IT resources in data centers in ways that were previously impractical when traditional infrastructures are replaced. The conventional process of making IT resources available to end-users, involving activities like hardware procurement, space allocation, software installation, and network provisioning, often takes months. Cloud computing streamlines this process through automation, business workflows, and resource abstraction, significantly reducing the time required to make resources available from months to mere minutes[04].

Additionally, through virtualization at the hardware and software levels, cloud computing has the ability to improve resource usage and reduce the need for IT hardware Network virtualization and path virtualization contribute further to resource abstraction and energy efficiency within routing processes. Cloud computing offers its services through three distinct models: software as a service (SAAS), platform as a service (PAAS), and infrastructure as a service (IAAS). SAAS caters to organizations accessed through the internet, PAAS provides development tools without necessitating software installation, and IAAS is managed by cloud service providers, supporting diverse operations encompassing storage, hardware, servers, and networking[13]. In aggregation, cloud computing provides the following facilities like;

Enable Cost Savings: By doing away with the requirement for upfront expenditures in physical hardware and infrastructure, cloud computing seeks to assist businesses in cutting expenses.

Improve Scalability: Cloud services are designed to be flexibly scaled up or down in response to demand, allowing enterprises to manage variable workloads more efficiently.

Enhance Flexibility: Cloud computing increases flexibility and mobility by allowing users to access resources and data from anywhere with an internet connection.

Foster Innovation: Cloud platforms facilitate innovation and experimentation within enterprises by enabling the quick creation and deployment of applications.

Enhance Collaboration: Team members can collaborate in real time with cloud-based tools and services, which facilitate easy resource sharing and communication.

Enable Disaster Recovery: Cloud computing offers robust disaster recovery capabilities, assuring business continuity in the face of unforeseen disasters.

Promote Sustainability: Cloud computing supports environmental sustainability initiatives by optimizing energy efficiency and utilizing pooled resources.

Improve Security: Cloud providers invest in advanced security measures to protect data and infrastructure, often offering better security than what organizations can achieve on their own.

Facilitate Automation: Cloud services enable automation of various IT processes, leading to increased efficiency and reduced manual intervention.

Enable Big Data Analytics*:* Cloud platforms offer scalable storage and processing capabilities, supporting big data analytics initiatives within organizations.

Support Remote Work: Cloud computing enables remote access to resources, applications, and data, facilitating remote work arrangements and enhancing productivity.

Ensure Compliance: Cloud providers often adhere to strict compliance standards and certifications, helping organizations meet regulatory requirements in different industries.

Improve Customer Experience: Cloud based applications and services can enhance customer experience by providing reliable, scalable, and secure solutions.

Foster Industry Collaboration: Cloud computing promotes industry collaboration by enabling organizations to easily share ***data, resources, and insights with partners and stakeholders.***

Bridge the Digital Divide: Organizations can help bridge the digital gap by providing cloud computing training programs to students, preparing the future workforce with essential skills and competence in new technology[19].

2.2 Cloud Service Models

Cloud computing includes three basic deployment models: private, public, and hybrid, but it also has unique properties such as the client-server model, grid computing, fog computing, and peer-to-peer computing. All the cloud deployment models offer different services such as Infrastructure as a service (IaaS), Platform as a service (PaaS) and Software as a service (SaaS) [16].

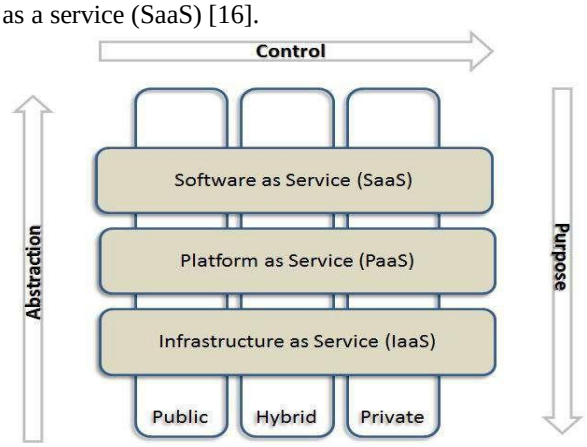

Figure 1. Cloud Service Models

i. Infrastructure as a Service (IaaS) : The cloud service concept known as **Infrastructure as a Service (IaaS)** involves the service provider handling all required hardware and internet connections. Users only need to manage the virtual machines hosted on this hardware and the software, including the operating system that runs on them. This service offers on-demand access to infrastructure components such as storage, computing power, networking, and support services (virtual servers). Users can access this infrastructure via the internet, allowing organizations to transfer their data to the cloud, which may lead to the elimination or downsizing of their in-house data centers. These services can be delivered by businesses or people using a variety of cloud deployment types, including private, public, hybrid, and community clouds[14].

Platform as a Service (PaaS) is a cloud service model in which users give the application they wish to deploy and the cloud service provider provides all of the necessary components to run this application, known as application hosting. This sits in the middle layer between SaaS and IaaS. PaaS provides operating systems and application development platforms that can be accessed and utilized over the internet[08].

ii. Software as a Service (SaaS) is a cloud service model where the service provider offers the software application and all the necessary components for its operation. SaaS is designed to be a complete solution for customers, offering convenience and ease of use. Many web-based ERP (Enterprise Resource Planning) software solutions are hosted on the SaaS cloud, providing accounting and business information services to users or customers[14].

iii. Community Cloud: It is exclusively for a set of users within closed group having a common goal[04].

2.3 Technological Challenges in Cloud Computing

Cloud computing is growing into a very appealing paradigm, as evidenced by its distinguishing characteristics. Notably, the on-demand self-service enables customers to easily access and manage resources without requiring direct engagement. A deliberate and measured service model enables organizations to adopt a pay-per-use approach. Heterogeneous networks facilitate resource pooling, serving multiple clients concurrently. Cloud computing boasts unlimited capabilities for users, characterized by its elastic nature[17].

- Security and Privacy: Paramount considerations involve safeguarding against malicious activities, spyware, and potential threats to privacy.
- Availability: Despite employing redundant systems, a commitment to continuous service, operating 24/7, ensures reliability.
- Confidence: Upholding confidence necessitates providing audits and security certifications, instilling trust in users or clients.
- Fault Tolerance and Recovery: The ability to operate seamlessly even after the failure of certain components underscores the importance of fault tolerance for system resilience.
- Scalability: Meeting changing user demands involves intelligently providing additional resources with efficient management.
- Energy Efficiency: Opting for microprocessors with lower energy consumption not only reduces electric charges but also enhances adaptability for widespread use.

In order to ensure a stable and reliable computing environment, these factors highlight the crucial elements of security, privacy, availability, confidence-building strategies, fault tolerance, scalability, and energy efficiency that must be carefully taken into account during the development and deployment of cloud computing systems.

2.4 Autonomous Cloud Computing

Autonomic computing, often known as self-adaptation mechanisms, is concerned with how computers can complete desired tasks on their own.”Self-*” systems are a popular way to describe these kinds of systems; the”*” indicates the sort of actions, such as Self-”configuration, optimization, protection, healing”. Figure4 shows the four properties of autonomic computing system[18].

A self-configuring autonomic system is one that can adjust to new conditions without external interference. Based on error signals or warnings issued by a monitoring device, the framework repairs faulty or outdated elements autonomously. Autonomic systems that can optimize themselves by decreasing resource overload and under-utilisation and effectively performing computing tasks are called self-optimizing. An autonomic system’s ability to self-protect means it is capable of warding off intruders and hackers. The system’s autonomic controller must additionally be able to recognize and avoid damaging attacks[02]. An autonomous system can self-diagnose, self-evaluate, and self-repair when it makes mistakes; no human interaction is required for this process, referred to as self-healing. This self-* attribute improves performance by reducing the impact of errors on execution, a feature known as fault tolerance. In an ideal world, self-managing and self-healing systems would never require human intervention (HCI) for setup or maintenance. When taken as a whole, the above-mentioned characteristics must fall under the supervision of self-managed systems[19].

Figure 2. Properties of Autonomic Computing System

Autonomous cloud computing has undergone the following transformations due to Artificial Intelligence (AI) and Machine Learning (ML):

Economic: Using computer systems instead of physical data centers has advantages. Cloud computing with AI makes the process easier in spite of the high upfront costs. AI systems have the ability to analyze data without human assistance.

Self-sufficient*:* AI-powered cloud computing has the potential to make process more intelligent, efficient, and insight-driven. AI could boost output in two ways: by automating repetitive and routine operations and by enabling data analysis without human interaction.

Data management: Real-time customization, anomaly detection, and administration scenario forecasting can be achieved by integrating AI with Google Cloud Stream statistical analysis.

Effective Decisions: The significance of intelligence-based data security is underscored by the growing growth of cloud applications. Tracing and analyzing network traffic is made possible by AI-powered security solutions. AI-powered systems can start an alarm response as soon as they notice an anomaly and important data is protected by this method.

2.5 E-Learning Process and Cloud Computing

i. Technological aspects

- *Technology-Driven:* As per the Technology Dimension, E-learning is all about delivering the content and conducting teaching and learning Programmes by using appropriate technology[04].
- *Delivery-System-Oriented:* This type majorly focuses upon the usage patterns of the services rather than the achievement of the outcome. It defines E-learning as a process of educational content delivery through an electronic system that includes all activities related to teaching and learning[04].
- *Communication-oriented:* This concept includes the usage of various communication and interactive tools for the effective transfer of information between the two parties. It defines as pedagogical interaction between instructors and students, students and students among the students through the World Wide Web by communication tools[04].
- *Educational-Paradigm-Oriented:* This views e-learning as a new side of education, it focuses on new developments and innovative breakthroughs in the existing educational system. In this perspective, E-Learning is defined as the usage of smart technologies to facilitate remote access to resources and services for better collaboration and exchange of ideas[04].

ii. Characteristics

The following features can be used to characterize an e-learning program[04].

- **Access:** How learners can access and utilize the program/course information is the main focus of this distinctive feature. There are two kinds of them. 1) Online: Through the use of internet-connected smart phones, laptops, and tablets 2) Offline: Using pen drives and hard drives Students and learners can access a variety of offline content on DVDs and CDs. Additionally, this mode is more effective because it is free from any internet connectivity interruptions, which might occasionally lead to irrelevant websites[04].
- **Learner Count:** This function check whether proper communication established among the students is not?

i) Individual: Interaction between Students/Learners will not be established for interaction, Learner will interact with the tutor, and the task will also be completed on a one-one basis only.

(ii) Group: A Group of learners/Students will communicate among themselves through discussion boards, open forums, e-mails, and chat rooms. Peer interaction is prominent between the learners, whenever they feel the

Programme /module /course doesn't suit them, they may drop [04].

- **Time**: It specifies the precise moment that students access information.

(i) Synchronous: In this process, the content will be delivered in real-time to the students through virtual platforms like teleconferencing and conference calls. The main limitation of this platform is differences in time zones because the learners are geographically scattered across the world[04].

(ii) Asynchronous: In this method, accessibility of the content has no time restriction, it can be accessed at any time .open forums and discussion boards are the main means for communication. It is helpful to get rid of the incompatibility of different time zones[04].

- Content Format: It defines which type of data and its format is being delivered.

i) Static: It means that the delivered content is through Programme/course/module is the same all the time. Here the continuity of the content can be well maintained. But still few learners /students withdraw as their needs may not be fulfilled through it.

ii) Dynamic: In this process, it is possible to respond more specifically to student/learner requirement, this overcomes the problem static nature, data or information can be modified and delivered to the respondents as and when it is required effectively, But it poses a challenge in creating new content every time and to sustain it for the long run[04].

Cloud computing plays a significant role here, facilitating the delivery and retrieval of information and content[02].

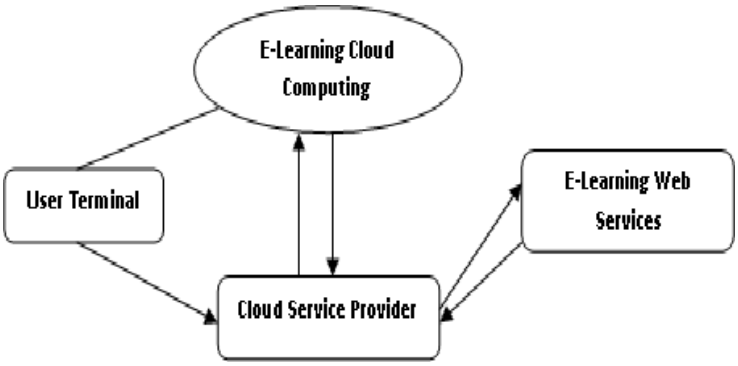

Figure 3. A cloud based E-learning framework

Compared to traditional learning environments, embracing SaaS applications holds the promise of robust and comprehensive distance learning, shedding light on the technological and pedagogical benefits of cloud computing. To effectively leverage online tools and interactive services such as teaching materials, recordings, and peer instruction, there's a need to pave the way for migrating to such a model[23].

Many educational institutions are already adopting cloud technology, signaling its promising future. Education SaaS refers to cloud-based e-learning systems that harness the benefits of cloud computing. With its minimal hardware requirements, it can be swiftly deployed by end-users. Additionally, it relieves the provider of system service and maintenance responsibilities, allowing them to focus on core business activities while ensuring automatic updates and providing essential resources via Web 2.0 technologies[23].

E-learning system architecture and cloud computing integration are critical for ensuring educational technology consistency, coherence, efficient resource utilization, and long-term stability. Consequently, subscribers save on software, deployment, and server management costs, leading to overall reduced expenditure for institutions, quicker deployment, and decreased IT workforce requirements. This becomes particularly advantageous in situations like the Covid-19 pandemic, where time is of the essence[01].

Programs that pay for material per use in educational settings can make it available to more complex programs and essential applications. Since Software as a Service (SaaS) servers are housed on cloud servers, many educational institutions can use them and take advantage of the inherent scalability. The software's performance remains consistent even as student usage increases. To instill consumer confidence and offer a comprehensive user experience, SaaS providers need to ensure a high level of security. Since consumer data is dispersed across various services, there's a growing need for platforms and data integrators in education to consolidate this data for a comprehensive view of the business[01].

Although cost is frequently mentioned as the main issue, there are additional considerations that should be made when using cloud services. Cloud storage eliminates the need for traditional hard disk backups and data transfers between devices. By creating a reservoir of information, students can retain their data for as long as needed, with the capacity to continue growing alongside them. The need for data recovery after a crash becomes almost redundant in this scenario, as there's minimal risk of data loss if the user's device fails. Additionally, by working from various locations, students can access and modify their files using virtualized programs, which

have proven particularly beneficial for educational institutions during periods of lockdown. This presents academic organizations with a cost-effective solution for their faculty, staff, and students[01].

The cloud simplifies data access monitoring by centralizing control in a single location rather than managing hundreds of scattered machines across a greater area. Moreover, since the cloud maintains a single database for all users, cyber security updates and enhancements can be efficiently assessed and implemented. Consequently, while there's still ongoing work to determine how cloud-related pedagogies impact learning assessments, from an academic standpoint, one of the cloud's primary advantages is its accessibility. Designed to facilitate collaboration from anywhere at any time, it enables reaching more learners beyond the traditional classroom setting and catering to their diverse needs. This broader accessibility allows for the provision of more meaningful information to a wider range of students across various contexts[05].

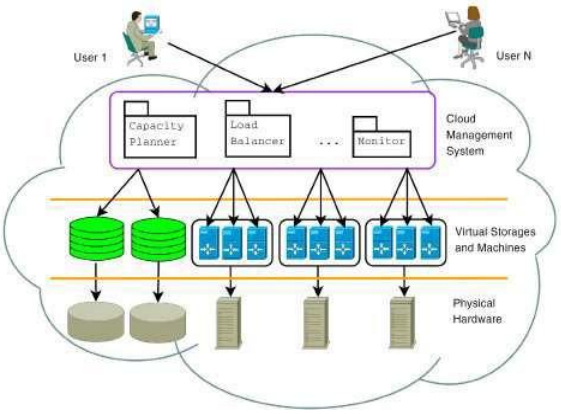

Figure 4.Cloud computing for E-Learning.

Most cloud e-learning techniques use three fundamental layers: a virtualized platform on top and a cloud management system and services layer underneath that. Two computer pools are used for teaching: a C pool with a thin client and a server pool running the hypervisor, with the private cloud architecture created using vSphere. It is possible to observe and manage all of the virtual infrastructure's hosts and services instantaneously using a web browser. Things like efficiency and configuration can be monitored along with saving alarm information and permission settings[22].

The integration of cloud technology and e-learning has received more attention from the institutions due to its high demand to continue education[18].

1. Major Issues in cloud-based e-learning:

- Data security and privacy.
- Multi-cloud environments.
- Performance challenges.
- Interoperability and flexibility
- High dependence on network
- Lack of knowledge and expertise
- Reliability and availability.

The Accessibility of essential resources refers to the ease of students/learners in obtaining/accessing resources for e-learning. These resources include connection to the Internet, bandwidth connectivity, browsing speed, etc. So there is a significant impact of accessibility of essential resources on the e-learning acceptance of learners[18].

The reliability of core infrastructure requisite for online learning facilitation was an influential factor in acceptance of the e-learning system. Infrastructure includes devices (computer, laptop, tablet, etc.) and communications network i.e. there is a significant impact of infrastructure dependability on the e-learning acceptance of students[18].

The important and even some major technological issues for the learners are to avail real-time data in different geographical locations in a cost effective and secured manner where there is no internet connectivity even during any natural disaster[18].

III. Related Work

In this paper we have proposed an autonomous cloud environment oriented framework that would allow the e-learning environment to perform effectively with real-time data in various geographical areas in an economical way, even in the event of a natural disaster when there is no internet connectivity[23].

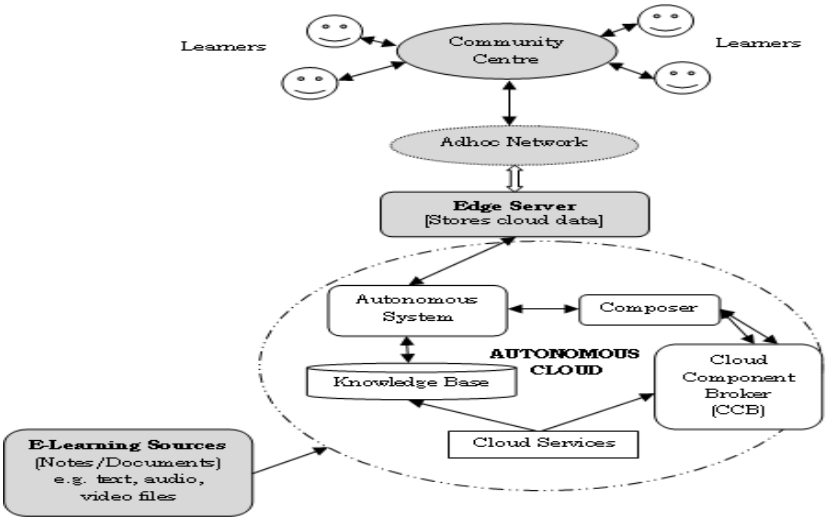

Figure 5: Proposed Framework

Sources for E-learning: Electronic learning, or e-learning, is a dynamic and successful approach to training and education. Text-based materials in Word, Excel, and PDF formats as well as video-based content (both live and pre-recorded video lectures) are common forms of e-learning tools[23].

a) ***Autonomous Cloud Environment:*** Automation and virtualization technologies are key components of cloud computing. Through the use of software called a hypervisor, IT organizations can use virtualization to create virtual instances of servers, storage, and other resources that enable numerous virtual machines (VMs) or cloud environments to operate on a single physical server. Cloud computing, to put it simply, is the provision of computer services—such as servers, storage, databases, networking, software, analytics, and intelligence—through the Internet, or "the cloud," in order to provide economies of scale, flexible resources, and quicker innovation[04].

b) ***Edge Server:*** Edge servers are specialized compute resources that operate at various points along the edge spectrum, which can range from on-premises edge to regional edge locations. These servers differ in nature depending on their deployment environment and specific use cases. They are a critical part of edge computing, enabling processing closer to data sources or end-users, thereby enhancing efficiency and reducing latency[11].

An edge node, a broader term, encompasses a cluster of edge servers or end-devices. The deployment of these servers can be in data centers or even as standalone units in remote areas. Edge servers play a crucial role in modern IT ecosystems, especially with the rise of the Internet of Things (IoT), 5G technologies, and distributed applications. By processing data near its source, edge servers enable faster insights and actions, essential in scenarios such as autonomous vehicles, smart cities, and industrial automation. Edge servers need to be designed to operate in environmentally challenging conditions with higher temperatures and humidity possible, compared to a climate controlled data center[18].

A system situated at the edge of a network, where data is generated and consumed, is known as an edge server. Edge servers are frequently found close to the programs or systems that generate the data they store.. They can be used to reduce latency, improve user experiences, and lower costs. In addition to this a local server is typically located in a data center or the cloud. The deployment of these servers can be in data centers, industrial settings, retail environments, or even as standalone units in remote areas[18].

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Edge servers are increasingly being integrated with technologies such as AI and machine learning. This integration allows for more intelligent and autonomous data processing capabilities, enabling edge servers to not only process data but also to make informed decisions based on that data[18]. As environmental concerns grow,

there's a significant focus on making edge servers more energy-efficient and sustainable. This involves optimizing hardware to consume less power and adopting renewable energy sources where possible[18].

c) *Ad-hoc Network:* When a conventional Wi-Fi connection isn't available, devices can join directly to form an ad-hoc network, which is a temporary wireless network for exchanging files or accessing the internet. It's useful for intimate events or circumstances in which establishing a complete Wi-Fi network is impractical. However, the ad hoc network vanishes and all connections are severed when the host device disconnects[18]. Ad-hoc networks play a pivotal role in emergency and disaster response scenarios. When traditional communication infrastructure is damaged or unavailable, ad-hoc networks enable first responders to establish communication channels quickly, coordinate rescue operations, and share vital information[18].

d) Mobile Ad-Hoc Networks (MANETs) are perfect for situations on the move, like disaster recovery or military operations, where setting up a fixed network isn't possible[18]. They're like mobile hotspots that devices can link to wherever they are. The benefits of choosing ad-hoc network are;

- *Flexibility*: The most significant advantage of ad-hoc networks is their flexibility. Nodes can join or leave the network at any time, making these networks ideal for dynamic and temporary situations. This mobility is particularly beneficial in emergency response scenarios where rapid deployment is critical[18].
- *Cost-Effectiveness:* Ad-hoc networks eliminate the need for expensive infrastructure, such as routers and access points. This cost-saving aspect makes them suitable for use in remote or underserved areas where building traditional network infrastructure is impractical or too costly[18].
- *Robustness and Resilience:* Ad-hoc networks are inherently resilient to failures. Since there is no central point of failure, the network can continue functioning even if some nodes fail or leave. This robustness is essential in mission-critical applications like disaster response[18].

IV. Results and Discussion

The suggested framework is put into practice to give end users access to the necessary data that is kept on the edge server, which uses the adhoc-network to store data from the independent cloud environment. Ad hoc wireless networks remove the need for complicated infrastructure configuration, allowing for rapid deployment anywhere, at any time.

The nodes located in different community centres at remote areas could access required data from the edge servers and the end users could use for their requirements. The adhoc-networks might be provided by the private and public service providers during the natural disaster days to continue information access at community centres from the edge servers.

However it is resulted with the successful transfer of data in form of text and message because of the limited bandwidth of the adhoc-networks and heterogeneous forms of information (text, message, audio and video files) at the edge servers.

The fundamental decentralized and self-organizing nature of adhoc-networks leads to performance issues which must be fully addressed to provide accurate and reliable communication.

To provide the end users with adequate information using their handhold devices such as mobile phones is a big challenge due the incompatibility of devices with the technology. Data security is a big concern here as the private/public adhoc-networks are used in the locality; VPN could be used to overcome this issue.

V. Limitations and Future Work

This proposed framework is capable of providing services on Text and Message to the receiver; however it can be further extended to increase the bandwidth of the adhoc-neworks, homogeneity of data to be accessed from the edge servers and the platform compatibility of handheld devices of the end users at the remote locations towards providing services on audio and video formatted information in addition to the Text and Messages[12].

VI. Conclusion

E-learning has become quite popular among students/learners worldwide, particularly during the quarantine period of the COVID-19 pandemic. This paper provides a framework to address some of the issues especially for the learners to avail real-time data in different geographical locations in a cost effective and secured way where there is no internet connectivity even during any natural disaster in autonomous cloud environment[18].Use of ad-hoc network restricts bandwidth and range of communication with increase number of nodes. In addition to these security concerns of this network due to its decentralized nature and implementing robust security measures in such a dynamic environment is challenging but crucial. For mobile ad-hoc networks, nodes are typically battery-powered devices. Maintaining constant communication and routing data can drain batteries quickly, posing a challenge for long-term or large-scale deployments. New technologies like 5G promise to make them faster and more secure, while artificial intelligence could help manage them better than ever before. [18].

However Human Computer Interface (HCI) will still play an important role in autonomous cloud environment. In addition to these the government should take the required actions to raise the caliber of learning materials by ensuring a steady supply of electricity, a reliable internet/adhoc-network connection, adequate educational/technical awareness for the learners , fully functional and interoperable technologies, the elimination of social inequalities, and reasonably priced network services[18].

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