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# ON MAKING CLOUD BASED E-LEARNING SYSTEM MORE RESILIENT

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**Abstract:** Cloud technologies in academic settings can improve and innovate the learning process by providing computational resources as a service (CC) over the internet. However, the quality of the cloud environment affects network services, affecting the quality of service (QoS). IoT (Internet of Things) can enhance learning efficiency, but learners in rural areas face challenges due to socioeconomic and geographic barriers. To address this, ad-hoc networks can be set up in remote areas to access text data. Additionally, eLearning activities should be personalized and standardized, allowing end-learners to access information according to their technological compatibility. This paper suggests an IoT-based eLearning framework that acknowledges local cloud storage resources for educational purposes and uses automatic customizable learning routes to deliver customized material to Cloud Learners.

**Keywords:** Cloud Computing, Autonomous Cloud, Edge Computing, Add-hoc Network, Remote Service Provider

## I. INTRODUCTION:

The use of cloud technologies in the academic setting has the potential to open up new avenues for improving and innovating the learning process. It became necessary to update teaching methods in response to the rapid development of new technologies. In order for them to achieve success, they needed to be able to learn whenever and wherever they desired [1].The Cloud Computing (CC) paradigm is a cost-effective solution for providing computational resources as a service.CC is an on-demand computational model that provides end-users with the services they require . The services available are delivered over the Internet and are characterized by their flexibility and scalability. As a result, innovative solutions must be created that can dynamically adapt to cloud elasticity. However, ongoing service must be ensured, as well as a high degree of performance. Furthermore, the quality of the cloud environment affects various network services[2]. As a result, any network failure, such as traffic delays or connections breakdown, has a significant impact on the cloud's quality of service (QoS).

Both students or users and teachers benefit from increased learning process efficiency when IoT is used in

the field of e-learning. All e-learners utilized smart phones, desktop computers, laptops, tablets, and other IoT devices throughout the COVID-19 pandemic.

On the other hand, learners in rural areas found it challenging to benefit from the e-learning process because of socioeconomic and geographic barriers to using suitable IoT devices with Internet facilities, as well as some security-related issues like data availability in real-time mode and on demand, which significantly limits the learners' ability to stay current with their curriculum[2].

In the meantime, the manufacturing of instructional resources has expanded quickly over time in form of text, image, audio and video etc. However, it becomes difficult on the parts of end users at the network challenged areas to avail the services but this could be managed to some extent with setting up ad-hoc networks in the remote areas to facilitate end users to access text data might be due to limited bandwidth. In addition to this, the use and reuse the learning resources in various eLearning systems when they are semi-standardized or unstandardized. Additionally, when using eLearning, the potential of systems and resources is not utilized. Furthermore, the potential of resources and systems is not used when eLearning activities do not properly personalize the entire learning experience[2,4].

It is important to provide the sources of information to the end-learners in form of path to facilitate autonomy to access their required information as per the technological compatibility of handheld devices and by utilizing a variety of automation approaches to construct a personalized learning route for individual learners using cloud resources[2].

This paper suggests an Iot based eLearning framework which acknowledges that resources stored in local cloud storage may be utilized for educational reasons. Additionally, automatic customizable learning routes will be used to deliver the customized material displayed to Cloud Learners[2].

## II. BACKGROUND:

For the following reasons, almost all businesses and individuals are choosing cloud computing services:

*Low Cost:* The potential for cost reductions is one of the strongest arguments for moving to the cloud. With the cloud, a lot of applications are free, and users can only pay for the programs they require[4].

*Scalability:* This measurable feature is one of the main justifications for using cloud computing. Universities, educational institutions, and the IT sector may easily scale up or down their IT requirements as needed thanks to cloud computing.

*Accessibility:* In a nutshell, cloud computing is easy to use and set up. Everything is available on the cloud, saving the user from having to install and/or move software systems. For exploitation, cloud computing speed should be improved [04].

### Challenges of Cloud Computing:

Although cloud computing seems to be a great help to end users, there are some challenges and problems with it. Security issues are the most crucial parts of cloud computing. Trusting a cloud provider with all of an organization's data and information, as well as running an application at someone else's location, is quite dangerous. Typical issues include threats, phishing, and data loss [04].Privacy and reliability must be maintained during data storage and transport. Due to the nature of this shared

infrastructure, user data, such as identity, operation history, and perceptive data, must be received from the cloud provider. Cloud is not liable for unauthorized use or retrieval when user administration and third-party access are not present. The general population has free access to a vast array of software, tools, and services. This implies that it is easy, straightforward, and rapid to take and use floating data without identifying or authenticating the user[2,4].

Because of excessive capacity use, a Cloud Service Provider (CSP) offers to provide a service but is unable to match the customer's expectations. Internet latency further hinders cloud computing, making it challenging for cloud service providers to provide services on schedule. Auditing the data in a particular service or application is the responsibility of both the end user and the cloud service provider (CSP).The Cloud Service Provider can copy, move, and change the data. In order to ensure that the Cloud Service Provider does not engage in these activities outside of their jurisdiction, clients must closely monitor all of these operations[1]. As a result, it is impracticable to audit all data, and it can be challenging to determine which data should be audited. In addition, cohabitation is a significant worry. The bandwidth allotted to each app decreases as the number of apps operating on a node increases, indicating an inverse relationship between the average number of apps and the allocated bandwidth. This puts the system's functionality at risk.

**Recent trend influential factors of cloud computing**

Cloud computing offers advantages, but it also has disadvantages. This can lead to major problems in some circumstances. Examples of actual cloud computing ghosts include the following[2,9].

- Security issues: A lot of businesses are worried about data security when they move to the cloud. Since they all share a single server, the cloud service provider is typically in charge of protecting the data of its clients. Although the cloud service provider guarantees data integrity, companies are still in charge of safeguarding their own data. Hacking and other security breaches are common problems. Customers will lose faith in a company's goods and services even if its data is inadvertently or intentionally disclosed [06].
- Performance challenges: Many companies are searching for cloud computing to enhance system performance in the current climate. This is a big issue for the company since if cloud performance isn't up to par, customers will move to another service provider. The speed at which web pages and applications load can significantly affect how many people utilize them. The delay might be caused by ineffective traffic splitting by service providers. In a fault-tolerance environment, it might be challenging to continue operating even if one or more components fail. [11].
- Network dependence: Because cloud computing involves the transfer of large amounts of data, high-speed networks are necessary. Data transfer across the network could be challenging with limited capacity. Even though they might lower the hardware costs, businesses need to invest more in high-speed networks to prevent financial losses. For small company organizations, network bandwidth—which can be costly—becomes a tremendous strain. [4].
- Lack of knowledge: Because cloud computing is complicated, it requires more research and takes a lot of time. A significant amount of expertise and experience are needed for this. Although this activity can be performed by many professionals in the sector, it is usually a well-paid occupation. For small business groups, this further raises the cost of doing business. [9].

- Lack of flexibility: When a company wants to switch to a different cloud-based service provider after investing in cloud services from a particular provider for a long time, it usually takes some reengineering. When moving from one cloud to another, flexibility is lost. [2].

**Cloud-based learning architecture:**

This model can be used to make the traditional classroom much more dynamic and functional, but it can also be utilized as a way to increase performance and flexibility in distance learning. In this approach, cloud services act as a CPU, physical memory, and middleware. To increase information and qualifications, these units must be used in conjunction with a range of flexible tools that have been created for academic institutions, field network designs, and internet-based technologies at a very cheap cost. Numerous benefits, including strong computing techniques, big storage capacity, high security, and visualization, can be covered by the proposed model, which also consumes a very small amount of resources. In order to proceed, learners and practitioners will send an initial request to the server, which will then manifest the user request and, upon acknowledgment, the services will be provided[2,9].

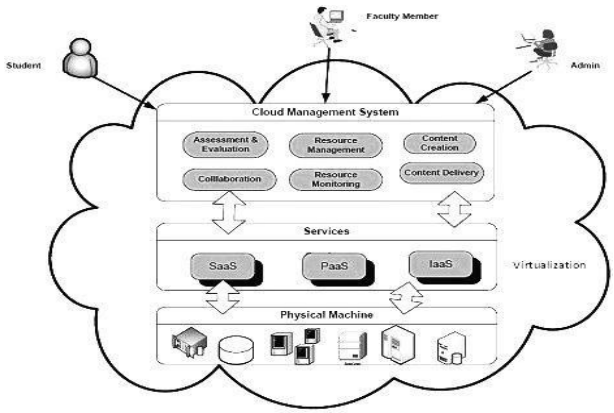


*Fig.1: Cloud Based Learning Architecture*

**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[9].

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[9].

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[4].

**Autonomous Cloud based e-learning**

An autonomous cloud environment oriented framework (fig. 2) 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[2].

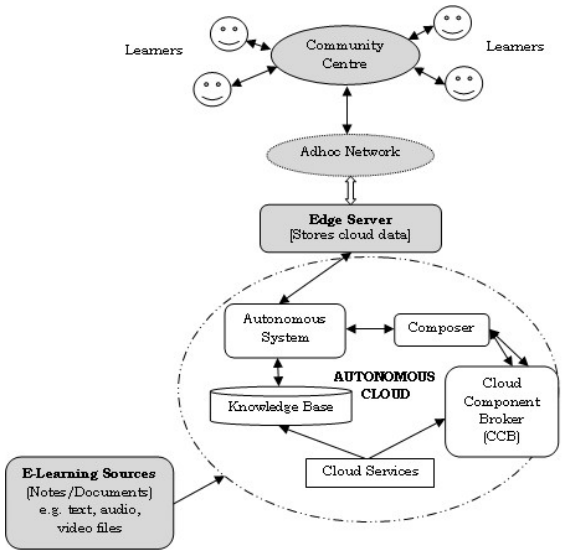


*Fig. 2: Autonomous Cloud Based E-learning*

***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[9].

**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 computer 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[9].

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[12].

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[8].

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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[9].

**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[9].

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[9]. 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[4].

*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[4].

*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[4].

**Research questions**

This paper aims to suggest model technology-enabled learning environments and related learning processes that might automatically personalize learning paths for all learners depending on their requirements at the community centers located at the remote locations during natural disaster and subsequently the learners can access the resources as per technological compatibilities of the hand-held devices.

**RQ1:** How can we provide the end-learners with information in forms of audio, video, images etc. as the adhoc-network established in the remote areas during natural disaster days are limited band width?

**RQ2:** How can it be possible to reduce the storage load at community centers those facilitate the remote learners to access their required information?

**RQ3:** How can it be possible to provide enough flexibility to the end learners using their hand held devices those are not technologically compatible to the quality of information being available on cloud?

## III. CONTRIBUTION:

A new paradigm of e-learning connected to the cloud technology called Remote Service Mediator need to be deployed at the community centre that will provide the learner about the path of their learning resources which can used by the learner to access the learning materials or information as per the technological compatibility of their hand held devices. Also the learners are also being prompted with adequate interactive messages about the status of their query with possible suggestions in case of any denial of services[2,4,9].

**System Block Diagram**

A block diagram showing major modules of the framework as follows;

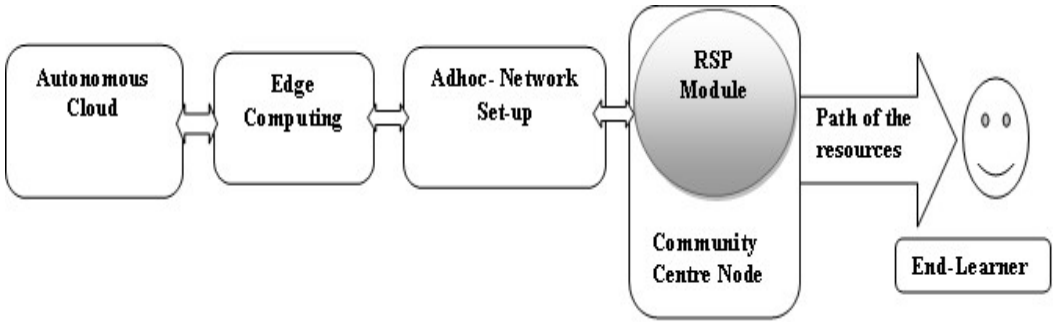


*Fig. 3: Block Diagram of RSP enabled autonomous cloud environment*

a. *Autonomous Cloud:* Autonomous cloud module is responsible for

- Proactive analysis: Monitors and analyzes services to identify potential issues
- Automation: Performs routine tasks without human intervention
- Optimization: Uses AI and ML to find ways to improve performance and cost
- Security: Helps customers meet regulatory compliance and exercise stronger security measures
- Disaster recovery: Uses backups to instantiate a peer database in case of a failover

b. *Edge Computing:* This module stores and processes data closer to the user rather than a remote data center, cuts down on delays and reduces latency, makes data processing more efficient by handling data right at the "edge" of the network, using devices like IoT sensors, gateways, or local servers. It is beneficial in real-time data processing and analysis[9].

c. *Adhoc-Network:* This module enables the end learners getting connected to the edge server temporarily during natural disaster with limited features such as distance, lower bandwidth and less secure. However this is the only set-up can be used for managing communications[9].

d. *RSP Module at Community Site*: Remote Service Provider can also be known as Remote Service Mediator with following functions such as;

- Live chat/messaging: Enables real-time communication between students and instructors for immediate questions, clarification, and support.
- Virtual office hours: Allows students to schedule one-on-one sessions with instructors or teaching assistants through video conferencing tools.
- Discussion forums: Provides a space for students to engage in asynchronous discussions, share ideas, and collaborate on projects.
- Technical support: Assists learners with technical issues related to accessing or navigating the e-learning platform.
- Tutoring services: Connects students with online tutors for personalized support on specific topics.

- Integration with LMS: The remote service mediator is often integrated directly into the Learning Management System (LMS) of the e-learning platform, providing seamless access to support features within the learning environment.
- Third-party tools: Some platforms may utilize dedicated communication tools like Zoom, Slack, or Microsoft Teams to facilitate remote interactions.

Benefits of a remote service mediator:

- Accessibility: Enables students to access support regardless of their location or time zone.
- Flexibility: Allows for personalized learning experiences by tailoring support to individual student needs.
- Improved engagement: Promotes active participation and interaction between learners and instructors.

**Design and Implementation**

1. **Choice of Programming Language**

   The cloud support learning system needs to effective and efficient. Also it should deliver content at real-time, as such a robust, efficient and easy to use programming language is required to develop the solution. The choice of programming language is PHP (Hypertext pre-processor) for server-side scripting, and Mysql as the back end database. Also, the above mentioned technologies are open-source technologies and are available for download for free[22].

2. **Input Design**

   The input design depicts the means in which users in general introduce data to the system for processing. These are initial part of the graphical user-interface which allows the user to interact with the system without necessary following a particular order. The user interaction with the system begins with the login form to collect the user's login credential and validates against the database. The credential are verified and validated by determining the roles each user can play in session. After a successful access to the system the user is greeted with a portal which serves as the dashboard. From here, the user can continue interaction with the system based on the predefined role. New users can find a link to a register and login to the system[22].

3. **Roles Perform by Users**

   The input stage allows the users (Learners, Instructors and System-Administrator) to login. New users can register. Students can download courseware (material such as text, audio, videos, presentations etc), view instructor schedule and participate in live classroom. Students can post questions to the instructors and participate in forum. Instructor can upload courseware, schedule class, initiate a class session and respond to questions from the students[22].

4. **Source of input to the system**

   The major source of input to the system include the mice-for initiating user initiating commands, the keyboard-for entering data in to the system through the forms provided and the digital camera/microphone for capturing video and audio data. Below are the screen-shot of interface that support user input[4,9].

5. **Output Design**

   The output defines the way the system responds to users interactions. It shows the various means it uses to present information to the users for decision making. The system presents information to users based on their roles. New users can get a confirmation or error message during the course of registration. The student can view or download courseware or participate in a live virtual classroom anchored by the instructor only when the technical feasibility supports

to access these facilities unless the user can access only the paths of the documents/files or services where these services actually stored or uploaded (web server or local Data Base) prescribed on their interface via an URL like complete path[4,9].

**6. Implementation**

This stage involves the various aspects that would be considered in order to put the new system to proper use and for it to deliver effectively and efficiently. It considers the factors that affect the successful running of the new system which includes: hardware requirement, software requirement, human-wares (users), testing, and documentation. Students can also study online directly with the instructor after booking an appointment[4,9].


*Fig. 4: Login Menu Screen*


*Fig. 5: Registration Form Screen*

*Fig. 6: Instructor Panel Screen*

## IV. LIMITATIONS AND FUTURE WORK:

The proposed frame work is suitable for establishing the community centre connectivity with the edge server during natural disaster, enabling user to access their required information by logging into the RSP module running within the community centre node[9].However due the bandwidth limitations of the ad-hoc networks establish temporarily and the technological compatibility of hand-held devices with the contents (text, audio and video message) under demand may not be fully available to the learners and to manage the communication within these bottle-necks, required address (URL) for information source can be provided to the learners. The limitations can be avoided by improving the bandwidth of the ad-hoc network, homogeneity of data, and technological improvement in hand-held devices and so on. [4,9].

## V. CONCLUSION:

In an independent cloud environment, this paper offers a framework to handle some of the problems, particularly for the learners who need to access real-time data in various geographical areas in an economical and safe manner even in the event of a natural disaster when there is no internet connectivity [2].With more nodes, the use of an ad hoc network limits the communication range and bandwidth. The decentralized nature of this network raises additional security problems, and it is difficult but essential to put strong security measures in place in such a changing context. When an unforeseen disaster strikes, the suggested framework can be used to connect the community center to the edge server. This way, users can obtain the information they need by logging into the RSP module that is running inside the community center node. In order to manage communication within these bottlenecks, learners can be given the required address (URL) for the information source [9].This is because of the temporary bandwidth limitations of ad-hoc networks and the incomplete technological compatibility of handheld devices with the contents (text, audio, and video message) under demand. By enhancing the ad-hoc network's capacity, data homogeneity, handheld device technology advancements, and other factors, the constraints can be circumvented. [4,9].

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