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PAPER

E-learning in the Cloud Computing Environment: Features, Architecture, Challenges, and Solutions

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ABSTRACT

The need to constantly and consistently improve the quality and quantity of the educational system is essential. E-learning has emerged from the rapid cycle of change and the expansion of new technologies. Advances in information technology have increased network bandwidth, data access speed, and reduced data storage costs. In recent years, the implementation of cloud computing in educational settings has garnered the interest of major companies, leading to substantial investments in this area. Cloud computing improves engineering education by providing an environment that can be accessed from anywhere and allowing access to educational resources on demand. Cloud computing is a term used to describe the provision of hosting services on the Internet. It is predicted to be the next generation of information technology architecture and offers great potential to enhance productivity and reduce costs. Cloud service providers offer their processing and memory resources to users. By paying for the use of these resources, users can access them for their calculations and processing anytime and anywhere. Cloud computing provides the ability to increase productivity, save information technology resources, and enhance computing power, converting processing power into a tool with constant access capabilities. The use of cloud computing in a system that supports remote education has its own set of characteristics and requires a unique strategy. Students can access a wide variety of instructional engineering materials at any time and from any location, thanks to cloud computing. Additionally, they can share their materials with other community members. The use of cloud computing in e-learning offers several advantages, such as unlimited computing resources, high scalability, and reduced costs associated with e-learning. An improvement in the quality of teaching and learning is achieved through the use of flexible cloud computing, which offers a variety of resources for educators and students. In light of this, the current research presents cloud computing technology as a suitable and superior option for e-learning systems.

KEYWORDS

cloud computing, education systems, e-learning, distance education, engineering education

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1 INTRODUCTION

Within the context of today's information society, educational institutions heavily rely on information and communication technologies. Educators can embrace innovative educational models and approaches, utilizing modern methods tailored to the needs and characteristics of the new generation of students and leveraging the tools at their disposal. Technology is an essential component of a high-quality educational experience. At this point, everyone is striving to take advantage of the benefits that technology offers in every aspect of life. One example of this is the instructors and students who are fully engaged with this technology through the tools and devices they use. The use of computers and other technological advancements is bringing about a shift in the way classes are conducted, introducing students to new methods of learning and engineering. It is common practice to refer to the twentieth century as the age of technology [1, 2]. At this point, technology plays a very significant role in our lives. The phrase "the basis of economic growth" refers to this specific issue. Technology has the potential to impact any field, including education, which is no exception. Advancements in technology have led to a greater emphasis on education and learning. A key focus is the integration of technology into the educational curriculum. When teachers first start using computers in the classroom, schools evaluate whether the implementation of educational technology has a significant and lasting impact on student development. The first thing that comes to people's minds when they hear the word "technology" is the concept of computers. Nevertheless, in addition to computers, there are various other forms of technology that can be used to enhance students' learning experiences [3]. Electronic learning and online education are emerging as active areas within the applied field of computer science, complemented by positive advancements in information technology. Electronic education encompasses a wide variety of educational processes, including computer-based education, web-based education, virtual classes, digital collaborations, and educational information delivered by various electronic media, such as the Internet, intranet, extranet, satellites, and video tapes. People have access to audio, compact discs, and other media products. The most significant distinction between mobile education and electronic education is the ability to provide education in any location and at any time. On the other hand, online education limits the students' mobility and relies on the individual being seated in front of their computer. Therefore, in situations where the use of computers (even portable computers) is not possible, electronic education will not be feasible [4–8]. In contrast, mobile training eliminates the need for a specific location, making it possible for individuals to benefit from this type of training regardless of their location, whether they are traveling or stuck in city traffic. In the process of developing software that millions of people can use as a service instead of running it on their personal computers, information technology specialists have encountered a great deal of new obstacles. Institutions interested in implementing e-learning face challenges in providing the necessary infrastructure, including servers, computers, storage space, and a network. Lack of the human resources needed to develop, implement, and maintain the e-learning system is a common challenge faced by most of these establishments. Cloud computing has gradually emerged as a new innovation pattern in the field of technology [9, 10]. This development has occurred alongside the advancement of information technology. Cloud computing is a concept that enables easy access to a shared platform within a network of adaptable computing resources (including networks, servers, storage, applications, and services) that can be quickly created and distributed with minimal administrative effort and interaction. In the field of

education, cloud computing offers benefits to students, teachers, and administrators. Cloud computing allows students to access their academic assignments from any location with Internet access. Additionally, teachers can quickly submit educational materials, and administrators can easily contact educators and parents while also saving information. The cloud computing model offers a cost-effective solution to the challenge of providing resources and services to a rapidly increasing number of students without requiring substantial investments in hardware and software. This makes the cloud computing model appealing to many educational institutions. On the other hand, one of the most significant benefits of cloud computing is the constant access to information and the various options for accessing and sharing that information. At present, cloud-based services are extremely important and are considered essential for modern education [11, 12].

1.1 Cloud computing

The effective management and organization of information and communication technology resources is made possible through the utilization of cloud computing, which is an innovative technique. The term "cloud computing" refers to a new paradigm in computing that provides the infrastructure needed to run applications as a service through a web browser and over the Internet. Cloud computing is a model that allows convenient and on-demand network access to a set of configurable computing resources, including networks, servers, storage space, applications, and services. These resources can be rapidly deployed by engaging with service providers with minimal preparation and management. Cloud computing is defined as a model that enables this capability. This technology has the potential to enhance capacity, talents, and abilities without requiring investments in new infrastructure, worker training, or software purchases [13]. The term "cloud computing" refers to any service that is provided in real-time through the Internet and is based on a subscription or pay-per-use model. This service type enhances the existing possibilities in the information technology sector. Infrastructure for cloud computing should support the following four fundamental elements [14–16]:

1. On-demand provision of self-service, which allows customers to utilize their virtual resources without needing to interact with the provider. This type of service also offers comprehensive network access, including access to the Internet, through various client platforms. It enables the management of smartphones, personal computers, and tablets.
2. The incorporation of resources and the provision of access to these resources are essential for many producers and for every authorized consumer to possess them.
3. The third option is estimated services, which automatically regulates the provision of services.
4. Metric patterns are used to optimize and measure the process of providing services to both the user and the supplier, with a focus on visibility and payment.

One definition of cloud computing describes it as "a new way of computing in which resources that are dynamically scalable and often virtual are provided as a service through the United States Internet Service." As a result, a large number of diverse end users can access the applications and data provided by the cloud. Internet access is available from a variety of companies and systems. Access can be obtained through the Internet. The cloud computing service can be accessed by

a variety of devices, including communication devices such as desktop computers, laptops, tablets, mobile phones, and iPads. As shown in Figure 1.

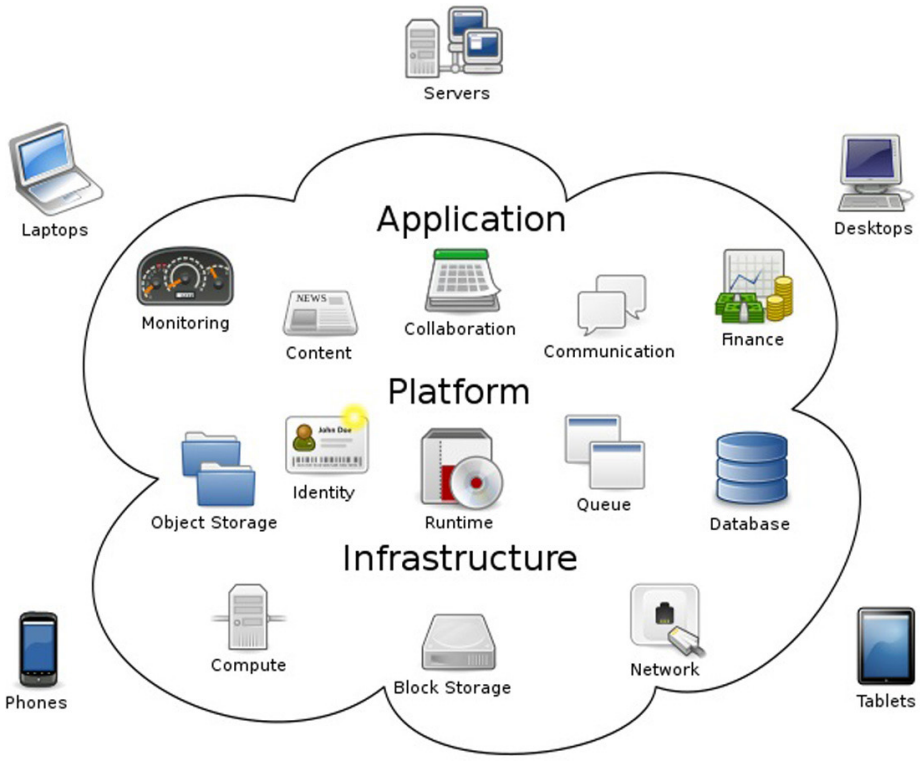

Fig. 1. Cloud computing services

Types of cloud computing. There are various types of cloud computing, and not all of them are suitable for everyone. Cloud computing is not a singular concept. There are many different types of services that have been developed to better meet your specific needs. This subsection provides details on the four distinct types of cloud computing that can be utilized to implement the service [17, 18].

The term "public clouds" refers to cloud environments that everyone can access without restriction. In order to accommodate a wide range of consumers, services are provided either at no cost or through a pay-per-user license model. The cloud environment is owned by a cloud provider and is independent of the company. True cloud hosting is exemplified by this deployment model. The public cloud and all its information technology resources are the responsibility of the cloud provider, who is also accountable for their design and ongoing maintenance.

Cloud computing used exclusively by a company or organization is referred to as a private cloud. Private clouds can be located on the company's premises or in a data center, both of which are owned and operated by the company or organization. Some businesses even pay a fee to maintain their cloud infrastructure. Private cloud infrastructure is located on the organization's private network, making it one of the services in this category.

The term "hybrid cloud" refers to a combination of public and private clouds integrated with technology that enables the sharing of data and applications between the two types of clouds. This has the potential to offer your company greater flexibility, expand the range of data deployment options, and help you upgrade your existing infrastructure and security standards.

Community clouds are designed to meet the needs of organizations that have similar requirements in terms of security, policy, and other areas. Community clouds can be managed by one or more member organizations, a third party, or an organization. The objective of the community cloud is to distribute server capabilities across users' devices, or a combination of these. Community clouds can be managed by multiple organizations, too.

1.2 Cloud computing service models

The majority of cloud computing services or models fit into three categories:

Infrastructure as a service. Infrastructure as a service (IaaS) refers to the provision and management of a crucial computing infrastructure within the virtual environment of the Internet. The scale is adaptable and can be quickly adjusted to meet both high and low demands. Additionally, it enables pay-as-you-go pricing. The expense and intricacy of buying and overseeing physical servers and other data center infrastructure can be circumvented with the assistance of IaaS. As each resource is provided as a distinct component of the service, you will only need to rent a specific resource for the duration you need it. While you are responsible for purchasing, installing, configuring, and managing your software (including operating systems and applications), a cloud computing service provider will organize and manage the infrastructure associated with cloud computing. The most fundamental component of cloud computing services. Under these circumstances, a customer is provided access to essential information technology infrastructure, including storage processing, networks, and other fundamental computing resources housed in the cloud. Users have the capability to create their own personalized computing environment and maintain full control over it. On the other hand, the cloud service provider is responsible for the maintenance and upkeep of all the physical IaaS equipment. The concept of virtualization is widely used [19].

Platform as a service. The term "platform as a service" (PaaS) refers to a component of cloud computing services that provides an environment for creating, testing, delivering, and managing application software. The fact of the matter is that each individual is allowed to develop their own applications. PaaS is a comprehensive cloud development environment that equips you with the necessary tools to create a wide variety of applications, ranging from simple cloud applications to more complex corporate applications. On a pay-as-you-go basis, you make purchases of the resources you need from a cloud service provider, and you gain access to those resources through a secure Internet connection. Similar to IaaS, PaaS includes infrastructure elements such as servers, storage, and networks. Additionally, it includes communication software, development tools, business intelligence (BI) services, database management systems, and other related components. PaaS is designed to provide support for the entire lifecycle of web applications, including installation, testing, scaling, development, management, and maintenance. PaaS allows you to decrease the cost and complexity of acquiring and managing software licenses, underlying application infrastructure, communication software, development tools, and other resources. PaaS also allows you to eliminate the need to manage these resources. You are responsible for managing the apps and services you design, while the cloud service provider typically handles the rest of the management [20].

Software as a service. Application software can be accessed via the Internet through a method known as software as a service (SaaS), which operates on demand and is typically based on a subscription basis. In most cases, users access the program

through a web browser on the internet. You rent the application for use by your organization and its users. A data center owned by the service provider houses all the essential infrastructure, application software, communication software, and data. The service provider is responsible for managing both the software and the hardware. They will also ensure the accessibility and security of your application and data by implementing appropriate terms of service conditions. Your organization can quickly develop and manage its business with a cost-effective and efficient application, thanks to SaaS [21] and it has been seen in Figure 2.

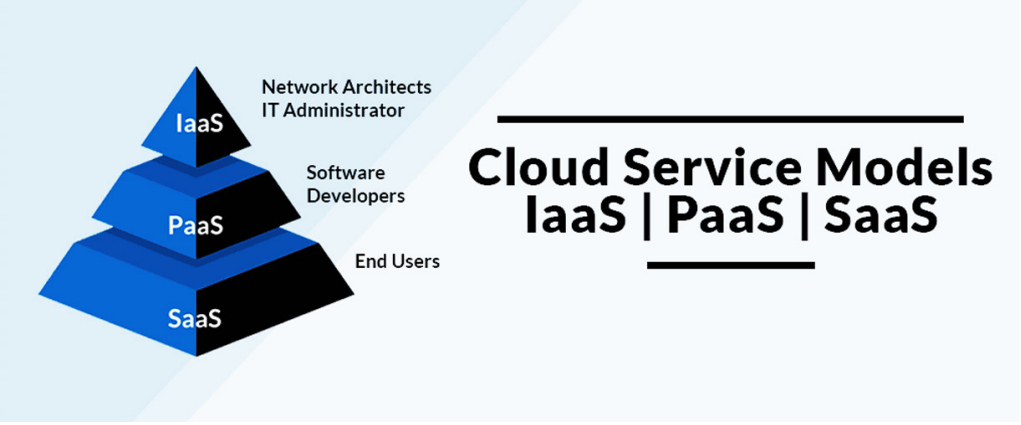

Fig. 2. Cloud computing service models

1.3 Cloud computing security

The issue of security is a primary concern that should be carefully considered when deciding whether to move to the cloud. Organizations should understand the tremendous opportunities that can be gained by utilizing cloud space. Additionally, it should have a reasonable level of security measures to address both existing and emerging threats. Naturally, we define security in terms of three criteria: keeping the secrecy of data, maintaining its accuracy, and ensuring its availability. The loss of direct control of assets and the possibility of inadequate management by the cloud service provider differentiate the security of the client's organization in the cloud space compared to traditional models. This lack of control can be viewed as the most significant threat in this accounting model [22]. In the hybrid and general cloud service models, as well as in the private service model, this issue represents the most significant security risk that may be encountered. When this happens, using cloud services requires transferring responsibility and control of some of the organization's information and systems to a service provider located outside the organization, either physically or logically [23, 24]. While the organization's responsibility for customer privacy, business information confidentiality, service continuity, and related matters is clearly not overlooked when transferring operational responsibility to the cloud service provider, it is also evident that this responsibility is not disregarded. Furthermore, there is a risk that the organization may become excessively dependent on a single service provider, leading to challenges in managing the transfer of data and services within the organization or to a different service provider. In fact, leveraging the benefits of cloud computing may lead to disruptions in the process of implementing changes or developing new services. Furthermore, when security incidents occur, they hinder the organization's ability to be agile, which is essential. The management of security threats in space should be a priority, and it

should be aligned with the service model (PaaS, IaaS, or SaaS) being utilized. The likelihood of a security threat arising in any of the three scenarios described above may not always be the same. Furthermore, it is essential to define the responsibility for establishing physical security, data, infrastructure, systems, and software in each model between the service provider and the customer. This requirement must be met. The way the two parties interacted with each other during the security incident needs to be clearly defined. Based on the information presented above, one of the most crucial requirements for customers to effectively manage the security of cloud computing is the security of cloud service providers. One of the reasons for this is that numerous efforts are being made to either modify the existing security standards or establish new security standards for cloud computing. To advance in cloud computing, it is essential to take innovative measures to guarantee security. In this context, the most crucial method is the use of private keys to encrypt data before transferring it to parallel machines [25–27].

1.4 Advantages of cloud computing in education

Cloud computing has the potential to have a beneficial impact on the infrastructure of remote education. Educational institutions aim to offer cost-effective alternatives to expensive and proprietary instruments by using electronic education systems and computer facilities such as online laboratories, computing centers, and data centers. The emergence of cloud computing has led to increased cost-effectiveness in educational systems. These resources can be used in any location, at any time, with minimal effort, and you are only accountable for the cost of their use. When it comes to requirements and budgets, this approach is worth considering [28]. As a result, with the increasing use of the Internet and computer networks, cloud computing has emerged as one of the most effective and cost-efficient solutions to address the requirements of educational institutions. Instead of using expensive and complex hardware and software resources, this can be achieved with the help of a cloud-based educational system. made available at reduced prices. Users have access to a wide range of options and benefits due to the integration of cloud services into electronic learning activities. Technology hosted in the cloud has the potential to enhance electronic learning systems in three different ways: infrastructure, software platforms, and services. The scalability of cloud computing is limitless, which is one of the significant advantages of this computing model [29]. This indicates that it provides a proportional amount of information technology resources based on your requirements. For example, adjust the computer power, storage space, and bandwidth based on the geographical location and the specific country. Setting up data centers on the premises of an organization usually involves a substantial amount of labor, including the installation of hardware and software as well as the completion of time-consuming activities related to information technology administration. The use of cloud computing eliminates these requirements, enabling the information technology staff to focus their time on achieving more significant business objectives. The most comprehensive cloud computing services available on the Internet are hosted in data centers that are completely secure and regularly upgraded with the latest and most advanced technology. When compared to corporate data centers, this approach offers several advantages. This includes putting an end to delays in the network and saving both time and space. In addition to enabling backup and disaster recovery, cloud computing also simplifies and streamlines the process of maintaining business continuity primarily due to the fact that the data can be generated in numerous additional locations that the cloud offers. The majority of cloud computing service providers offer a wide range of rules, technologies,

and controls that improve your overall security posture. These measures are designed to protect your data, applications, and infrastructure from any potential threats that may arise [30]. Table 1 summarize the advantages of cloud-based e-learning.

Table 1. Advantages of cloud-based e-learning

System User	Advantages of Using Cloud Computing Technology
Programmer of information technology department	Develop applications without worrying about scalability.
	Optimizing resource allocation and increasing the possibility of virtualization.
	In case of problems, quick replacement of servers located in the cloud without much cost and damage.
University or relevant company	Reducing resource management costs including electricity, gas, and water.
	Eliminate or reduce the costs of scientific camps, meals, rental of buildings, or educational equipment.
	Payment is based on usage, which depends on the number of users. In this way, using rich applications with high cost is easily possible.
	Reuse of prepared educational content.
	They are protecting the environment using green technologies.
	We are adapting to the increasing speed of technological progress.
	Changing security policies and techniques can be easily tested and implemented.
	Data access control will be easier, as only one location control is required.
	The scale of the computing infrastructure can be increased or decreased according to the need, thus maximizing the investment profit.
	Since the application runs on cloud servers, the system will have high scalability.
Teacher	Constructive and comfortable communication with the student according to his learning speed, at desired times.
	Providing lesson contents and exercises at different levels of beginner, intermediate, and advanced at the right time.
	Using different technologies and providing a deep understanding of the lessons for students.
	Flexibility and easy use of multimedia facilities such as video and photos.
	Increased efficiency without additional responsibility for the teacher.
	Increase your knowledge and skills in the field of Internet and computer.
Student	Constructive and comfortable communication with the professor at desired times, especially for students who are not comfortable in public.
	Holding classes for people who have problems in terms of work or geographical location, bad weather conditions, etc., where it is not possible to physically attend the classrooms.
	Using lesson contents that suit your learning speed and not having the stress of fast teaching.
	Scheduling your classes at the desired time and not at pre-defined times.
	Increase your knowledge and skills in the field of Internet and computer.

2 E-LEARNING

The term "e-learning" refers to a system that provides these services either independently or in combination with more traditional forms of education. To achieve its goals of elevating the scientific and cultural level of society and preventing the outflow of material resources and scientific capital to other states, this system utilizes the capabilities and facilities provided by the Internet and other modern technologies. Learning through the use of the internet enables colleges to disseminate information on a massive scale [31]. E-learning is an educational approach that relies on information and communication technology and encompasses a wide variety of applications. Some examples of these applications include internet-based education, computer-based education, and virtual classrooms. In other words, the term "e-learning" encompasses a wide variety of application software, information-based learning methods (such as computers and CD-ROMs), networks, the Internet, intranets, and virtual institutions that provide education to participants in any area, at any time, and in any location. Despite the fact that the terms "e-learning" and "online learning" are sometimes used interchangeably, "e-learning" is, in essence, a specific type of online learning. The implementation of e-learning is dependent on both the instructor and the student being in the same physical location. The elements that comprise e-learning are as follows [32–34]:

a) **Instruction over the Internet:** Web-based instruction is a form of training that utilizes computer technology and relies on the World Wide Web. Individual study forms the basis of this type of training, which can also be supplemented with group instruction. During this training, it is possible to assess users' learning and provide training center managers and instructors with the ability to view user scores. When there are a significant number of students, it is advantageous to deliver instruction via the internet. Within the context of this training, it is possible to establish connections to databases and to incorporate images, graphics, music, and text into the session. Furthermore, there is an opportunity to participate in conversations, share knowledge, and create online discussion groups using the Internet.
b) **Asynchronous virtual classroom:** The asynchronous virtual classroom is an online learning environment that uses a variety of network and Internet technologies to connect instructors and students in an asynchronous manner. With this arrangement, everyone utilizes the learning area in a shared manner, but each individual has their own time to access this learning space and review what occurred in the classroom. In addition to being able to review questions and answers, receive feedback from teachers, access reports of the work done by other students, and find other helpful information, students can also ask questions or make points. One of the advantages of this type of education is that it partially considers the social aspects of the educational environment as well as the interaction and communication among individuals in the same profession.
c) **Synchronous virtual classroom:** A synchronous virtual classroom is a real-time learning environment where students and teachers can work simultaneously, even though they are in different physical locations and connected through computer networks. Additionally, this indicates that the semester is held at the same time. Furthermore, it is essential for all individuals to be present simultaneously, which is one of the limitations and drawbacks that add to the technical complexity of the system.

Students have the opportunity to choose and register for courses offered online by the university using a virtual university, which provides an online learning environment. Lessons are delivered online, examinations are taken digitally, and students interact with their instructors and classmates through electronic communication. The terms "virtual university" and "e-learning" are used to describe any form of educational program that is delivered in a manner that is not the conventional face-to-face technique. The course content can be conveyed online using videos, dynamic images, and interactive features in both directions. In addition, textbooks can be transmitted via cable or satellite television, or they can be stored on CDs, DVDs, or videotapes, or they can be a combination of these formats. Through the use of virtual procedures, every department of the Virtual University is functioning.

2.1 Cloud computing in e-learning system

The daily tasks have become easier with the help of software, thanks to the advancements in computer technology and communication technologies. It has been seen in Figure 3. With the help of application software and a virtual learning environment, one of the technologies that has simplified learning is known as e-learning. E-learning is used by numerous educational institutions and universities for their distance learning programs. When compared to more traditional approaches to e-learning, the current version of e-learning incorporates a variety of cutting-edge technologies, enabling it to provide its users with superior services that are less complex. At the same time, one ongoing issue is the demand for a substantial amount of hardware infrastructure and software resources for e-learning. Moreover, numerous educational institutions lack the financial resources necessary to provide these materials [35]. Cloud computing technology has the capability to fully utilize technological advancements and associated innovations. This technology utilizes the Internet and remote centralized servers to keep programs and information data up-to date. Due to the unique characteristics of the cloud environment, there are numerous opportunities for the development of educational systems. The use of cloud computing enables consumers and organizations to access applications regardless of the conditions at their physical locations. In addition, it allows customers and employees to access their personal information files from any system or computer by connecting to the Internet. Cloud computing technology facilitates the centralization of bandwidth, data processing, and storage to ensure the efficient execution of computer tasks. As a result, cloud computing is a technology that utilizes computing resources, including hardware and software, delivered as a service over a network or via an Internet connection. The term "cloud computing" originates from the shape of a cloud, representing intricate and interconnected infrastructures and frameworks. This definition includes diagrams of cloud computing systems, as well as user information, calculations, and software programs that rely on remote services [36]. On the other hand, electronic learning can be defined as the use of technologies that enable online assessment, training, learning, and knowledge extraction. The term "e-learning" is associated with a teaching and learning approach that relies on the Internet and incorporates technological advancements. E-learning utilizes the latest educational technology currently available, along with vast resources, to provide newer and more effective teaching techniques. To meet diverse user demands, such as those, for courses and on-demand access to laboratories in order to offer more flexible courses tailored to specific knowledge requirements, cloud computing can offer compelling tools for both teachers and students.

One example of this is the capability to utilize computing resources. The students deliver the service based on the time and location requirements. Furthermore, it helps educators develop lesson content that is customized to meet their specific needs. The use of cloud-based electronic educational infrastructures reduces the obstacles that educational institutions face. These challenges include the need for fast and efficient communication, reducing supply costs, improving flexibility, providing access, and addressing concerns about privacy and security. This system, on the other hand, will not be able to replace the role of the teacher's performance; instead, it will serve as a supplement to the entire educational process. In fact, the cloud-based e-learning system leverages cloud computing technology to create an electronic learning platform. This enables the utilization of all the benefits that cloud computing offers to enhance the effectiveness of electronic learning [37].

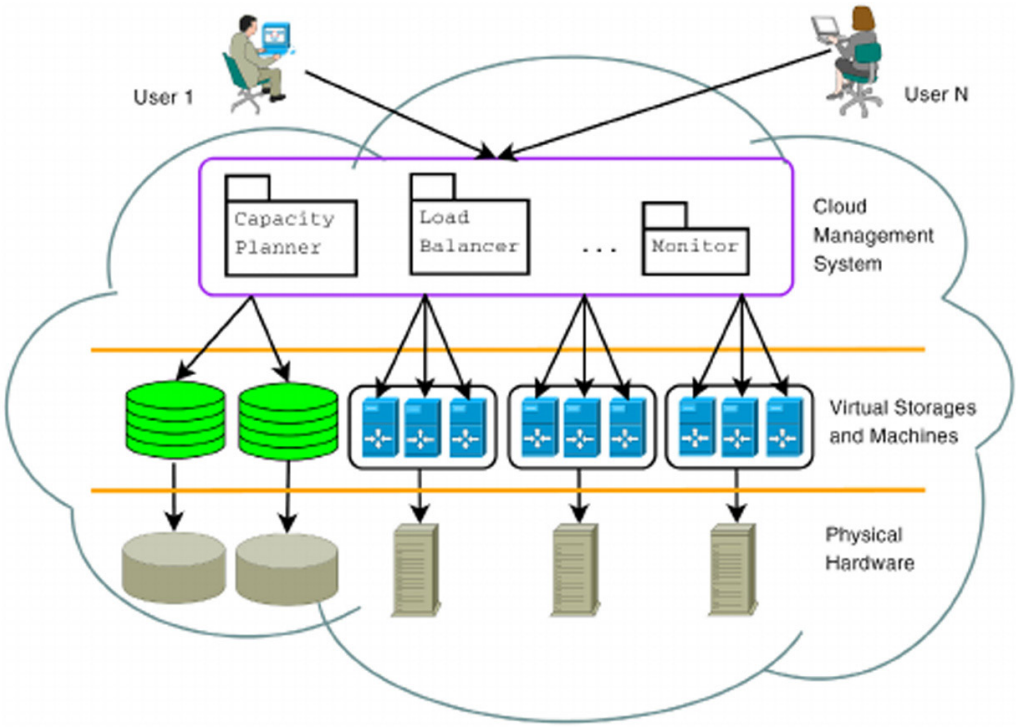

Fig. 3. E-learning environment based on cloud computing [38]

2.2 E-learning architecture based on cloud computing

Within the realm of distance education, the implementation of cloud computing is a method that has the potential to enhance both performance and flexibility. In addition, this model has the capability to create a standard classroom that is both highly dynamic and efficient. The cloud services act as the middleware, the actual computer memory, and the processor to implement this paradigm [39]. To ultimately improve information quality and the overall quality of information, these units should be coordinated with tools and networks that utilize a variety of technologies and architectures in educational and university institutions. The utilization of this paradigm, which relies on a set of highly constrained resources, has the potential to yield numerous advantages, including enhanced computing power, expanded storage capacity, virtualization, and improved security [40]. In the

beginning, the student submits a request to the server without any prior knowledge of cloud computing. The server receives the request and then provides the service to the user. Finally, the student receives a confirmation. The user's request is transmitted to the management system, which then searches for the relevant resources and calls the appropriate services at the right times. These services are responsible for locating the necessary resources in the cloud, running the appropriate online applications, and creating or accessing the required documents. The monitoring and measuring components of the system are responsible for tracking the utilization of the cloud and allocating resources to users simultaneously [41]. This occurs after the web application has been executed. Figure 4 illustrates the architectural paradigm of cloud computing-based e-learning.

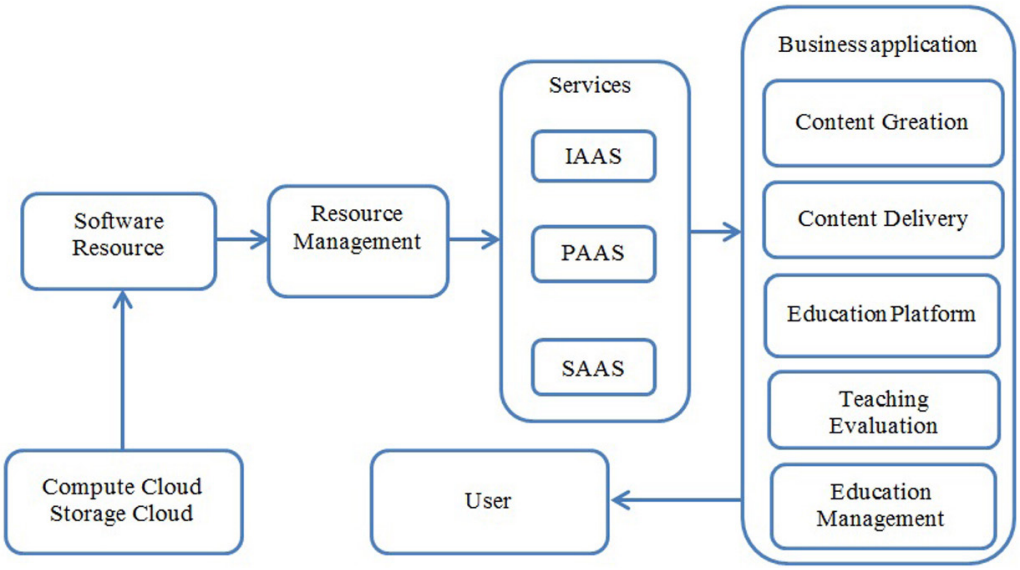

Fig. 4. E-learning architectural model based on cloud computing [42]

3 CHALLENGES AND SOLUTIONS OF CLOUD-BASED E-LEARNING SYSTEM

The current state of the economy and the knowledge society has gained have made online education a financially viable and environmentally sustainable tool for training individuals. The success of online education depends on the creation of virtual platforms that not only replicate the advantages of traditional educational tools but also overcome the associated challenges and problems through the use of technology. On the other hand, cloud service providers and manufacturers are responsible for ensuring environmental safety while providing maintenance and training. It is possible for any security weakness to lead to mistrust among all stakeholders. In a similar way, although convenience is the most significant aspect of e-learning, one of the most critical concerns is the availability and reliability of services [43]. In addition, service providers must offer an adjustable service level agreement because the proportion of students enrolled in each individual course or institution varies. Furthermore, network bandwidth is a significant obstacle that hinders users from fully benefiting from all the services that cloud-based educational institutions have to offer. The deployment of fiber optic networks is a strategy that can be implemented to enhance the delivery of cloud resources for the

online learning environment. On the other hand, the educational programs offered by institutions need to be compatible with cloud-based systems. To achieve this, it is crucial to have a reliable technical support system in place. The complexity is another crucial issue to consider, as the existing system's complexity needs to be simplified. In addition to the significant challenge of addressing security and privacy concerns and hazards associated with cloud computing, one solution is to store the data on servers located in undisclosed locations. Securing the stored data is the issue. As a result, data must be encrypted before being stored on cloud-hosted servers. The organization's strategy may be affected by the lack of monitoring and control of the cloud which may lead to failure to meet its security requirements, decreased confidentiality, accuracy, and availability of data, as well as reduced efficiency and service quality. Cloud computing competes with two different approaches to information technology. When it comes to the internal infrastructure of information technology and its support, the ownership of servers and personal equipment, as well as the responsibility for their maintenance and management, falls under the purview of private institutions. Outsourcing management services is also part of the internal infrastructure of information technology and its support. The outsourcing management services model is similar to that of cloud computing. In this model, service providers are responsible for the maintenance and upkeep of servers and other equipment. The architecture of cloud computing has an impact on the provision of information technology services and consumer models used in e-learning. Additionally, it changes the traditional methods of using computer technology. The establishment of a robust framework for cloud-based e-learning and the widespread distribution of cloud-based e-learning applications to users are both essential measures to address the aforementioned issues. E-learning can utilize cloud computing to provide the necessary infrastructure and a platform that can enhance efficiency, scalability, and accessibility. Cloud computing enables the widespread and straightforward implementation of technology-enhanced learning in a short period of time. This is achieved without requiring specialized infrastructure or personnel experienced in the specific field. The concept of cloud computing refers to a delivery mechanism that provides convenient and comprehensive access to network resources. It enables quick and convenient access to a wide range of computer resources, including networks, servers, storage space, applications, and services, without requiring server involvement in configuration. With cloud computing, on the other hand, the barriers to entry into the software sector are greatly reduced, and cloud service providers are offered new opportunities for businesses to generate revenue [44]. This research aims to implement a mobile education system within the framework of cloud computing for educational purposes. Initially, the architecture and service models of cloud computing are investigated, followed by an exploration of e-learning in cloud computing. Afterward, the advantages of cloud computing are presented to illustrate the importance and necessity of utilizing cloud-based e-learning. To ensure satisfactory speed and efficiency, the system should be implementable via cloud access and have fewer issues compared to similar systems.

4 CONCLUSION

The purpose of the paper was to present innovative teaching methods that enhance the accessibility of computers and information technology. The integration of cloud computing with e-learning introduces a new concept for the advancement of e-learning. This innovation has the potential to revolutionize the current state of

education and training. While modern technology offers numerous benefits, it is crucial to acknowledge its negative aspects, including limitations, bandwidth, security, and regulations for educational administration. Various solutions have been proposed to address these challenges. Cloud computing is a relatively new and advanced model for storing and retrieving data via the Internet. Cloud computing has emerged as a new technology due to its ability to dynamically scale and efficiently use resources, regardless of software or hardware. The new technology of cloud computing reduces the costs of education and infrastructure while expanding public access to education. The widespread availability of mobile devices, such as smartphones, tablets, and laptops, makes cloud-based remote education a feasible option for achieving educational equity, especially in underserved regions. With cloud computing, students have the flexibility to access and share a wide range of instructional resources from any location at any time. Migrating e-learning to the cloud can bring numerous benefits, including virtually limitless computer resources, excellent scalability, and reduced costs. Various resources for teaching and learning are accessible through flexible cloud computing, enhancing the quality of education. This research concludes that cloud computing is the most suitable technology for e-learning platforms.

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