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Utilization of Cloud Computing for Learning in the Pandemic Era of Covid 19

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***Abstract*—The impact of the COVID-19 pandemic has greatly affected human activities from various sectors, one of which is the education sector. In the face of this pandemic, educational institutions are instructed to conduct distance or limited learning. Distance learning can be done online by utilizing information and communication technology (ICT), one of which is cloud computing technology. This paper aims to identify and provide an overview of the use of cloud computing technology in learning in the era of the covid 19 pandemic. The method used in the presentation of this paper is the Literature Review methods. The number of relevant articles was obtained as many as 50 articles published in the 2017-2021 range. The results show that the utilization and use of cloud computing technology is currently one of the research trends, cloud computing-based learning can be in the form of e-learning or mobile and can be developed in combination with other technologies. The use of cloud computing technology in the education sector has many benefits, both during the pandemic and after this pandemic ends.**

Keywords—cloud computing, e-learning, mobile cloud computing, distance learning, covid 19 era

I. INTRODUCTION

The development of information and communication technology is currently growing rapidly, so as to create a single information environment at the institution is available and provides many opportunities for the implementation of distance learning. One of the technologies that are currently being developed is cloud computing [1]. Cloud computing is internet based computing through various shared resources including software, and information is provided for local devices to data center, software is considered as a service while applications and data are stored on servers to be linked via internet [2,3]. Cloud Computing also plays an important role in education. Cloud Computing facilitates planning, collaboration, and communication and also supports individual learning in online project-based design activities. Instructors demonstrate the roles of mentoring, technical support, administration and communication [4]. Cloud computing has a significant impact on teaching and learning processes and offers an easy way for educational accessibility, especially in remote areas for students and staff who have the opportunity to access multi-application platforms through virtual classroom web pages, either at home or at university [5].

The issue for which the pandemic occurred was first reported on December 8, 2019 and identified on January 7, 2020 as COVID-19. In March 2020 to stop the spread of covid 19, various countries declared a health emergency [6]. In the era of the Covid-19 pandemic where health protocols require restrictions on mobility and maintaining distance, educational institutions in almost all of the world are required to adjust learning conditions by conducting distance learning [6,7]. The COVID-19 pandemic is an unprecedented situation, with an unpredictable timeline [7]. Covid 19 has caused the sudden suspension of schools, colleges, universities and other government institutions [8]. Impact on learning there is a transition from face-to-face learning to distance learning or online [6,8,9]. Based on the research results of Shahnawaz Khan and Mustafa Raza Rabbani that the learning transition that occurred did not run smoothly [10]. Findings from research Emmanuel Aboagye also revealed that students are not ready to get online learning experiences in this pandemic era [11]. Distance education is now a solution not only in mandatory situations such as the lockdown pandemic, but also as a support to facilitate the educational process, in face-to-face and virtual learning to reach students wherever they are [12]. Online classes are conducted in virtual classrooms where students and teachers are not within visual reach. These arrangements rely solely on information technology (IT) infrastructure and digital computing platforms [13].

Cloud computing technology plays a very important role in the field of education, especially in the application of distance learning during the covid 19 pandemic. Current research trends on cloud computing have focused on the technology, application, costs, benefits, and security of cloud computing at the organizational level in small companies. and medium. Little research attention has been paid to the adoption and use of cloud computing in educational institutions and how contextual factors may influence the diffusion and adoption of cloud computing [14]. This is one of the authors' attractions to examine more deeply related to its use. Thus, the purpose of this paper is to explore the use of cloud computing technology in learning in the era of the covid 19 pandemic. The method

used in this paper is the library review method on several articles from various journals that have been published between 2017-2021. This paper is organized into five parts, namely introduction, method, results, discussion, and conclusion.

II. METHODS

The method used in presenting this paper is by conducting a literature review related to the use of cloud computing technology in learning during the covid 19 pandemic. The databases used in this systematic literature review include: google scholar, taylor & francis Online, sage journal, and science direct. Generally, articles published from international journals and the results of proceedings are in the 2017-2021 range. The literature search was carried out using keywords relevant to Cloud Computing in education, namely: cloud computing, education, online teaching, e-learning, covid 19, distance learning, LMS, and cloud learning. The literature search strategy was based on meta-analysis of the database with the help of Harzing's Publish or Perish software, then selected, Articles that match the next keyword will be picked up (eligible), while those that don't match will be ignored (excluded). Articles that match the keywords are articles that are selected (included), then reviewed to get a summary of each article. The number of selected articles is 50 articles published in the 2017-2021 range. The details of the number of articles and the scope of the study can be seen in the table 1 below:

TABLE I. LIST OF SEARCH ARTICLES RELATED TO CLOUD COMPUTING IN LEARNING PUBLISHED BETWEEN 2017-2021

Year	Amount	
	Article	*Scope*
2017	10	Online project based learning, Cloud Computing (CC) and schools, the usefulness and effectiveness of cloud-based applications in supporting learning, CC in e-learning, e-learning architectural systems, moddle, mobile CC.
2018	9	Use of CC tools, Validation of rubrics for evaluation of cloud content, Use of cloud technology for collaboration, CC in e-learning, cloud-based VLE, cloud classrooms, Factors influencing the use of CC, usability and effectiveness of cloud-based applications in supporting learning .
2019	13	CC in e-learning, CC technology application performance evaluation, promotion program in CC market, Use of Google Cloud and IBM Blue Mix Services, CCT adoption stage, cloud platform selection, cloud resource management, CC mobile optimization, cloud capacity development, library based cloud, Power data mining system based on CC Hadoop platform, Effectiveness of cloud resources, scheduling methodology and limitations that must be overcome in CC.
2020	13	CC-based e-learning, Massive Open Online Courses (MOOCs), Digital Footprints, CC convenience and friendliness, impact of covid 19 on CC technology, benefits of CC in education, Cloud integrated IoT for education, Technology Acceptance Model (TAM), transition from face-to-face learning to online learning, mobile CC, distance learning, adaptive learning.
2021	5	CC-based Education Models, mobile education, distance learning, learning during the covid 19 pandemic, online learning readiness, M learning in the covid 19 era.
Total	**50**	

III. RESULTS

The core technology of cloud computing is virtual technology, which virtualizes various components in cloud computing into a pool of resources, unified deployment, flexible deployment, universal virtual platform for extending, migrating and backing up various application data [15]. This is in line with Gull Bibi's opinion that cloud computing provides a group of computing resources with dynamic scalability and the use of virtualization as a side-to-side internet service. This technology is more affordable and cost effective with centralized data storage, processing and bandwidth [16,17]. Cloud computing is a new innovation and has been widely used and utilized in various fields, one of which has influenced the form of teaching and learning in the education sector [18]. Based on a review of 50 articles that have been reviewed by researchers related to the use of cloud computing technology in education and learning, especially in the era of the covid 19 pandemic, in this section the researchers divide into three main parts, namely: 1). Cloud Computing research trends in education, 2). Utilization of cloud computing technology in the era of covid 19, 3). Cloud computing-based learning.

A. Cloud Computing Research Trends in Education

Researchers examine research trends related to cloud computing in education and learning in the range of 2020 – 2021. To find out trends in this research, researchers are assisted by software Harzing Publish or Perish to find articles relevant to the topic. This software includes the keywords Cloud Computing, education, cloud learning, e-learning. The data sources were taken from Google Scholar, 200 articles related to the topic were published from various journals. After obtaining the article data in the form of a RIS file, the researcher continued to analyze the data using VOSviewer software based on the title and abstract of the article. The results of the VOSviewer software are shown in the image below:

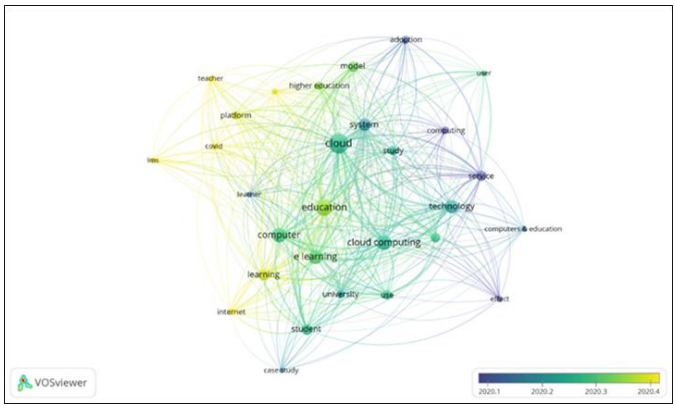

Fig. 1. Visualization of Cloud Computing Research Data in Education in the range of 2020-2021

Based on Figure 1, it shows that cloud computing technology has had a lot of influence in the field of education, this can be seen from the large green and yellow circle marks,

where cloud computing or cloud technology has a lot to do with education, e-learning, study, student, learning, university, higher education. This is one of the researchers' perceptions that research related to the use of cloud technology in education and learning is one of the research trends in the 2020-2021 range. This shows that in that year education has used cloud computing technology a lot in learning, especially in the era of the COVID-19 pandemic. In line with opinionVasiliki Matzavela and Efthimios Alepis that computer-based learning has experienced very rapid growth which includes e-learning, mobile learning (m-learning), online courses through social media, and the benefits of affective computing [19]. However, there is still limited research related to the use of cloud computing that is associated with the COVID-19 pandemic, this is shown by the yellow circle mark on the keyword "covid" which is still small and has little relationship with other keywords. Thus, it can be the basis for future researchers to conduct research based on the research gap. This is in line with the opinion Sabi et al [14] namely the limited research attention on the adoption and use of cloud computing in educational institutions and how contextual factors can influence the diffusion and adoption of cloud computing [14].

B. *Utilization of Cloud Computing Technology in The Era of Covid 19*

In the era of the COVID-19 pandemic, technology has an important role and contribution in the implementation of online distance learning. One of the technologies that contribute to distance learning is cloud computing technology. Cloud Computing has many advantages such as simple sharing, fast deployment, lower costs, and convenient processing [20]. In terms of services, there are many services provided by cloud computing. The three main service models are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) [21,22].

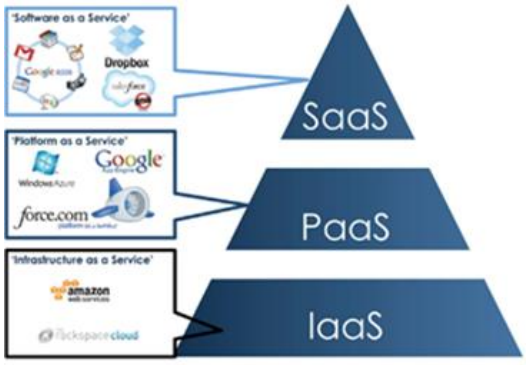

Fig. 2. Layers for cloud computing services [23]

In the SaaS model (figure 2), pre-built applications, along with the required software, operating system, hardware, and networking are provided. In PaaS, the operating system, hardware, and network are provided, and customers install or develop their own software and applications. The IaaS model provides hardware and networking only; customers install or develop their own operating systems, software and applications [23].

Based on articles that have been reviewed by researchers, there are several applications of distance learning by utilizing cloud computing technology, including E-learning based on Cloud Computing [8,18,24,25], Mobile Cloud Computing [20,26], Virtual Laboratories and Virtual Computer Lab (VLVCL) [10], Google Apps including Gmail, Google Drive, Google Classroom [18,27], Zoom Cloud Meeting [28,29], and others. In this pandemic situation, well-known companies like Google, Microsoft, Zoom and Slack have offered many features of their products that can be useful in the field of free education to educational institutions. According to the report recorded by Microsoft team the users were 750 on March 10 but on March 24 it has increased to 138698 with significant growth [18].

C. *Cloud Computing-Based Learning.*

In this section, researchers will describe the findings of cloud computing-based learning based on a literature review of various articles that have been determined. Whatever the findings of this cloud computing-based learning will be divided into two main parts, namely E-learning based on cloud computing, and Mobile Learning.

1) Cloud computing-based e-learning: Cloud computing based on e-learning systems is a continuation of the previous generation program, referred to as web-based e-learning, although it is considered traditional [30]. The concept and implementation of cloud computing shows that cloud computing technology can be an evaluation in improving the quality of learning, the quality of information, and can support all activities in higher education institutions and organizations more stable, and better controlled [31]. The development of e-learning has resulted in innovative functions to assist the educational and learning efforts of teachers and students. Many educational frameworks and functions, especially e-learning, have been introduced in recent years. Therefore, understanding the intention of teachers and students to use cloud-based e-learning applications is very important [18]. E-learning in particular has proven useful during this COVID-19 crisis [8].

Cloud-based e-learning systems often pay attention to the demands of educational institutions such as resource virtualization, centralized data storage, low operating costs, scalability, flexibility, and availability of e-learning systems. Therefore, cloud-based e-learning architecture is partially big using e-learning approach in Cloud [32]. The cloud-based e-learning system architecture is divided into three main layers. The first layer is the Cloud Management System Layer. It represents the interface of the e-learning system with the cloud environment. This layer consists of several management subsystems that allow the integration of e-learning practices in the cloud computing model. The second layer represents the

virtual machines that are implemented in the system and that provide cloud services. It provides three types of cloud services: SaaS, Paas and IaaS. Users use the software over the Internet. They don't need to buy software and hardware or maintain or upgrade them. Finally, the third layer is the physical hardware layer, which includes all the physical architecture of the system. This layer represents the information infrastructure and all the resources used. It also represents for the learner basic computing power such as physical memory, CPU The physical host pool is dynamic and scalable. This means that new physical hosts can be added to increase physical computing power for cloud middleware services [23] (see figure 3).

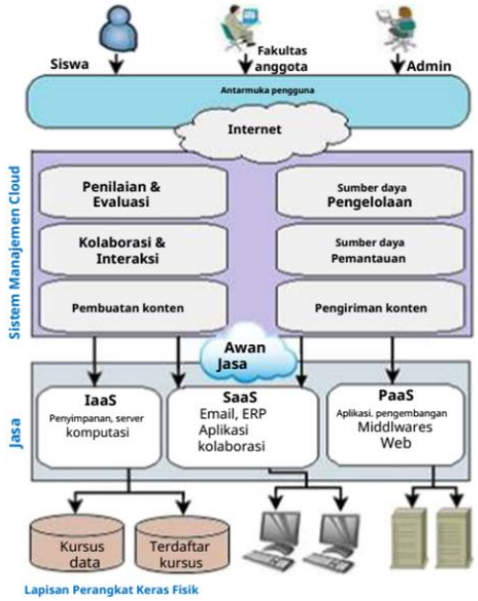

Fig. 3. General architecture of cloud-based e-learning system [23]

In another study conducted by Purwono Hendradi, he has proposed the architectural design of a Cloud-based E-learning System which refers to the development of Education 4.0. namely by considering the five attributes of the Education 4.0 profile and the Cloud E-learning Architecture layer. Five attributes of education 4.0 include: teachers, content delivery, learning process, learning organization, and students. While the architectural layer includes: infrastructure, software resources, services, and applications [33]. In the Cloud-based E-learning system architecture, the program enters the Education 4.0 era by adding Artificial Intelligence (AI) which is parallel to Industry 4.0. The AI impact described is in three layers, including Services, Resources and Business Applications [33,34].

In-Service Layer, there are three models from cloud providers and the presence of AI makes every service dynamic and includes the Education 4.0 era. Among the three cloud services, Software As a Service (SaaS) is very important in AI in Education 4.0. At the Business Application Layer, AI has a dominant role. Connect Attributes from Education 4.0 profiles with layers in Business Apps. Figure 4 below shows the proposed cloud-based E-learning System architecture with three layers, including Services, Resources and Business Applications [34].

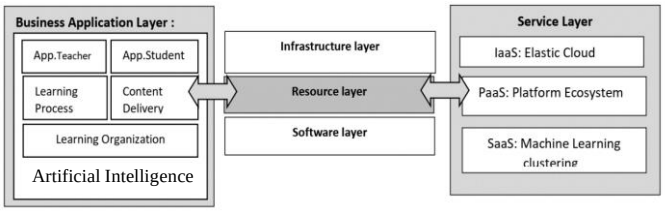

Fig. 4. Proposed cloud-based e-learning system architecture in education 4.0 [34]

2) Mobile cloud computing: Mobile Cloud Computing (MCC) is considered as the best solution to overcome related to storage, battery life, mobility and security. Mobile cloud computing (MCC) which is currently in great demand, especially in the education sector, is a combination of cloud computing and mobile computing. Mobile Cloud Computing is a platform that combines mobile telephony and cloud computing services. In Mobile Cloud Computing (MCC), data storage and processing is carried out remotely from the mobile phone in the cloud [20,35]. Mobile Cloud Computing (MCC) is changing the way students learn. Applications can be made in a form that can be used with smartphones and therefore allow students to access learning modules faster and faster with this cloud computing system. These modern technologies encourage students and help them achieve their academic goals [20] (see figure 5).

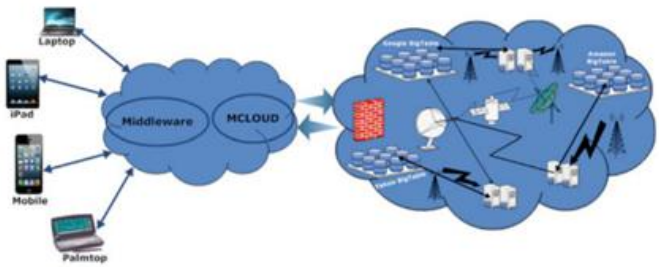

Fig. 5. Mobile Cloud Computing (MCC) [35]

The basic architecture of MCC has two cellular networks A and B. Mobile networks A and B can have devices connected via wireless access points, satellites, or base stations. Different network services like database, home agent (HA), authentication, authorization and accounting (AAA) run on the servers available on the mobile network. Mobile user requests are executed by a central processor; which is directly related to the server. After that, on the basis of HA and user information stored in the database, the mobile network operator provides users with AAA services. After this process, the user's credentials exit the mobile network and are linked to the cloud (owned by the data center owner or cloud service provider) via

the internet, When the user enters the cloud, the cloud controller connects the user' the credentials with significloud cannot depend on the service credentials requested by the user. Users can request various types of services such as computing resources, virtualization, applications, databases, and cloud storage services [35] (see figure 6).

Fig. 6. Mobile cloud computing architecture [35]

IV. Discussion

The current Covid-19 pandemic has affected the activities and lives of everyone from various sectors. One of them is the education sector which is feeling the impact of the spread of Covid 19, where academic activities are carried out remotely suddenly, both in the learning process and in school administration services. The government urges all educational institutions to carry out online distance learning, and employees are asked to work from home (WFH). At the beginning of the transition from face-to-face learning to distance learning, there were many problems and challenges faced by teachers, educational institutions, students, and parents.

The role of technology, especially information and communication technology is very helpful in solving these problems. One of them is cloud computing technology. Based on the literature review conducted by the author regarding the use of cloud computing technology in education, there are some interesting findings to discuss in this section. Research trends in the use of cloud computing technology have been widely studied in the 2020-2021 range. This shows that the use and utilization of cloud computing technology increased during the covid 19 pandemic. Distance learning carried out online during the COVID-19 pandemic by schools, had used a lot of cloud computing-based media, such as google classroom, zoom cloud meeting, Gmail , google drive, Microsoft teams, cloud-based e-learning, and more.

Cloud computing technology will continue to grow in its utilization. One of them is cloud-based e-learning used in education. This cloud-based e-learning was developed before the onset of covid 19, so users of this technology are not so foreign and rigid in using it. Even in the era of the industrial revolution 4.0, cloud computing-based e-learning is collaborated with Artificial Intelligence (AI) by considering the five attributes of the 4.0 education profile and the Cloud E-learning Architecture layer. Five attributes of education 4.0 include: teachers, content delivery, learning process, learning organization, and students. While the architectural layer includes: infrastructure, software resources, services, and applications. There are three types of cloud services: SaaS, Paas and IaaS. Among the three cloud services, Software As a Service (SaaS) is very important in AI in Education 4.0. In addition to e-learning, cloud computing is also developed and implemented in the form of a car, which is called Mobile Cloud Computing (MCC). MCC is considered to be the best solution for dealing with storage, battery life, mobility and security issues. MCC is currently in great demand, especially in the education sector.

Cloud computing has many benefits for the education sector, especially during the COVID-19 pandemic which requires learning and working remotely. Even before covid 19 appeared, the education sector had used cloud computing technology a lot. Based on the results of a literature review, it shows that many studies have identified and explained the benefits obtained when using cloud computing, compared to the challenges or obstacles that occur. This is a consideration for users to choose the use of cloud computing technology in solving problems that occur in distance learning. Along with technological developments that continue to develop in the era of the industrial revolution 4.0, researchers assume that the challenges that occur (internet connectivity, security and confidentiality, of the various uses of cloud computing technology in education, it is certainly interesting to discuss the role of students and teachers in this online learning. Although this technology helps in learning, it cannot eliminate the role of teachers as educators and instructors in learning. Referring to the research conducted by nal akiroğlu & Turgay Erdemir in online project-based learning, that teachers and students have their respective roles when distance learning by utilizing cloud computing [36]. Student roles include (1) cooperation (2) coordination, (3) communication, (4) leadership, (5) investigation, (6) practitioner, (7) providing effort and (8) taking responsibility. While the role of the teacher or instructor is guidance, providing technical support; administrator, manage communication, managers, active technology users, and learning assistants.

V. Conclusion

The trend of cloud computing research in the education sector in the last year (2020-2021) continues to increase, and has had a lot of influence in solving education and learning problems. The use of cloud computing in the COVID-19 pandemic era has been widely used by teachers and students in conducting online distance learning, including:E-learning based on Cloud Computing, Mobile Cloud Computing, Virtual Laboratories and Virtual Computer Lab (VLVCL), Google Apps including Gmail, Google Drive, Google Classroom, Zoom Cloud Meeting, and others. The use of cloud computing technology will continue to grow and be used in learning, even though this pandemic ends.

Cloud computing-based learning will continue to develop in various applications or other platforms. One of them is e-learning based on cloud computing and Mobile Cloud Computing (MCC). The cloud-based e-learning architecture consists of three main layers. The first layer is the Cloud Management System Layer, the second layer represents the virtual machines that are implemented in the system and that provide cloud services, and the third layer is the physical hardware layer, which includes all the physical architecture of the system. In the industrial revolution 4.0 era, the development of cloud-based e-learning architecture is influenced by Artificial Intelligence (AI) technology. The MCC is a platform that combines cellular telephone and cloud computing services. The basic architecture of MCC has two mobile networks that has the device connected via a wireless access point, satellite, or base transceiver station (BTS).

The application of cloud computing in education has many benefits, including: virtual classrooms, accessibility, cost-effectiveness, secure data storage, scalability, wider scope, ease of sharing, easy to use and friendly to users, accessibility, and easy group work in collaborating. However, there are several challenges in using cloud computing in education, including internet connectivity or signal interference, privacy, security, trustworthiness, and high demand in complex applications.

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