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LEVERAGING CLOUD COMPUTING FOR TELEMEDICINE: ADVANCES IN MEDICAL IMAGE COMPRESSION, SECURITY, AND SAFETY

Ni Luh Bella Dwijaksara*[1], Safrian Andromeda[2], Putri Alief Siswanto[3], Agrippina Waya Rahmaning Gusti[4], Bahar Amal[5], Nurani Masyita[6]

[*1,2,5,6] Universitas Singaperbangsa Karawang, Karawang, Indonesia
[3]Institut Teknologi Sepuluh November, Surabaya, Indonesia
[4]Politeknik Elektronika Negeri Surabaya, Surabaya, Indonesia

*** Email: nfebriyanti@ft.uniska.ac.id**

Abstract
Telemedicine has revolutionized healthcare delivery by providing remote medical consultations. This study explores the role of cloud computing in enabling telemedicine, with a particular focus on the utilization of medical image compression techniques and ensuring robust security and safety measures. The integration of cloud computing with telemedicine offers numerous advantages including scalable storage, flexible computing resources, and improved accessibility to medical data and applications. One critical aspect of telemedicine is the transmission and analysis of medical images such as X-rays, CT scans, and MRIs. However, the large size of these images can pose challenges in terms of the transmission speed and storage capacity. To address this, medical image are employed to reduce the size of images without a significant loss of diagnostic information. Security and safety are paramount in telemedicine systems, particularly when dealing with sensitive patient data and medical images. Cloud computing provides a robust infrastructure for ensuring data security and privacy, enabling the secure transmission and storage of medical images. This abstract discusses the implementation of encryption, access-control mechanisms, and authentication protocols to safeguard patient data during transmission and storage in the cloud. By leveraging cloud computing technologies, telemedicine can overcome geographical barriers and enhance healthcare accessibility for patients and healthcare professionals. Exploration of these topics will contribute to improving the efficiency, reliability, and quality of telemedicine services, ultimately leading to better patient outcomes and increased healthcare accessibility in both urban and rural settings.
Keywords: *Cloud Computing; Compression Techniques; Medical Image; Telemedicine; Security and Safety*

INTRODUCTION

Telemedicine refers to the use of technology to provide medical support. The word "tele" means far away from Greek. Telemedicine essentially refers to providing medical help from far away[1]. The introduction of telemedicine has led to numerous alterations, thereby revolutionizing the healthcare industry. Communication technologies, such as video conferencing or phone calls, can be used to remotely connect doctors or healthcare providers. Implementing technology as virtual appointments offers a more convenient way to receive

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primary healthcare services without leaving home. If patients are concerned about their health, they can seek advice from other professionals. The doctor reviewed the medical images, including the outcomes of the examinations, relevant background details, advancements in the medical field, and diagnostic imaging, which were sent by the expert for assessment[2].

Medical images establish guidelines for their transmission, storage, reception, processing, and display. Because medical procedures are complex and detailed, the associated images require considerable resources to be saved and sent correctly. This is especially true in situations where immediate diagnosis is needed. In some cases, doctors from different places need to look at and talk about one image simultaneously to find the correct diagnosis[3].

Healthcare institutions require large amounts of computing resources to use local processing and storage. Even when there is good infrastructure, system scalability becomes a problem when data sharing is needed to make diagnoses and treat diseases more efficiently. In this situation, using computers in the cloud has become a great solution because they can manage services and users well, allow payment based on usage, and easily adjust resources to ensure good service[4].

The demand for technology in healthcare services has recently increased. Cloud computing, telemedicine, artificial intelligence, and electronic health records often offer improved services. Cloud computing involves obtaining different services through the internet. These resources include tools, programs, and equipment used for storing data, connecting to the internet, and running computer programs. Instead of buying computers or data storage buildings, companies can rent access to storage and processing from cloud service providers. Cloud computing is widely used for sharing devices such as servers, networks, storage tools, and software applications. In simpler terms, cloud computing users can use the internet to access their programs and information. More industries, including healthcare, use cloud technologies[5].

Owing to the popularity of implementing Cloud Computing in Telemedicine today, the purpose of this literature review is to explain the use of Cloud Computing in Telemedicine, especially in the transfer and storage processes in the form of medical images. From this activity, it is hoped that things that have been learned will be known, which can be further developed in relation to cloud-based telemedicine in medicine. Based on the above explanation, the problem is how to use Cloud Computing for Telemedicine applications.

What is telemedicine?

Telemedicine may be a health-related benefit with the assistance of telecommunicating and electronic data advances. It alludes to the entirety collection of deliverables planned to enable patients and their doctors or healthcare suppliers. It incorporates a wide extend of employments, counting online persistent discussions, inaccessible control, tele-health nursing, and farther physical and psychiatry recovery. It permits superior wellbeing care choices, increments crisis benefit quality and execution, diminishes time in making a determination, and spares costs for both specialists and patients by advancing clinical strategies and lessening travel costs to clinics[6].

Telemedicine has expanded get to to high-quality healthcare offices. Patients will presently receive more repeated clinical administrations. They can to meet the finest therapeutic suppliers basically by utilizing video application

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computer program, interviews can be taken from a remote place, and clinicians have better-suited devices for organizing, information capacity, report administration, and leveraging each other's aptitudes. This advances the quality of therapeutic hones, permitting specialists to spend less time on country assignments and providing more care to patients. Telemedicine moreover empowers. Private health care pros to hone and enhance patient involvement. Patients will not be able to stand in long lines, and doctors will be able to understand data more helpfully and productively with electronic records and disposing of in general hold-up times. Moreover, further arrangements permit specialists to commit less time to each persistence, permitting them to treat a more noteworthy number of patients[6].

Cloud Computing

In its most fundamental frame, cloud computing involves putting away and obtaining information and programs over the web instead of on a computer's difficult drive. Clients who use cloud computing do not claim the infrastructure; instead, they lease it from a third-party provider. On-demand self-service, wide arrange get to, asset pooling, and fast flexibility are the basic properties of cloud computing and cloud administration. The ubiquity of cloud computing is increasing because of its numerous preferences. One component that permits associations to convey cloud administrations is the dodging of tall program permit costs. They depend on the web. Cloud resources are open to the organization at any time and through a standard strategy that empowers the utilization of different stages[7].

MATERIALS AND METHODS

In this study, the Systematic Literature Review (SLR) method was used to learn and understand information related to the main research objectives and topics. SLRs were arranged based on PRISMA guidelines (Preferred Reporting Items for Systematic Review and Meta-Analysis)[8]. Method used has three stages of flow consisting of stages planning (planning), stages of implementation (conducting), and reporting stages. At the planning stage, the context of the article search will be determined and research questions will be used as the basis of treatment in the literature. The next stage is to search for reference materials or literature sources (the search process). The last stage is reporting and summarizing the results of proposals for research and discussion activities, as follows:

A. Research Questions

A list of research questions can be created based on the research needs of the topics discussed. The following is a list of the research questions in this Literature Review.

1) RQ1: What are the research objectives in related articles?
2) RQ2: What development methods are used for Cloud Computing in the health sector?
3) RQ3: In what activities is Cloud Computing often used in the health sector?

Fig.1. Stages of Systematic Literature Review (SLR)[9]

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B. Search Process

1) WATASE

The process of searching for scientific articles in this Literature Review was a database search from Scopus using WATASE software. The WATASE program is an online system designed to collaborate with the researchers. It was initiated in 2018 and developed by involving researchers from several universities in 2020. WATASE was created to facilitate researchers in conducting joint research (collaborative research).

2) Zotero

Zotero is a free application based on Open Source which is a type of program in citation management (citations, references, and bibliographies). This program can be installed on any type of computer, such as Linux and Windows, and can even be used on the Mac iOS. This application can compile a system of citations, references, and bibliographies. Therefore, the thing that is most disliked in the process of writing references, especially bibliography in scientific writing, becomes easier to do with the help of Zotero[10].

C. Keyword Search

In this WATASE software, an identification process is carried out by entering the keyword "Telemedicine Using Cloud."

D. Criteria and Limitation

The selected year, i.e. 2013-2023. From the search results, the author found 16 articles that analyzed telemedicine over a period of 10 years from the period 2013-2023. The goal is to make it easier to map or classify the searched articles.

E. Quartile

At this stage, the articles obtained were screened to determine the research topic will be discussed. Article filtering will be performed based on quartiles and years of publication. The first filter was based on the quartiles. In Quartile 1, there were 10 studies on the topic of Telemedicine, Quartile 2, there were 1; Quartile 3 there 4, Quartile 4, 1, where, in Q1, Q2, Q3, and Q4, including articles. While articles outside the 2013-2023 range, there are 2 studies related to Telemedicine and research that do not contain an abstract; they are excluded:

In this case, the author only choose to study the eligibility of the selected articles.

1) The articles used were related to the research topic regarding the application of Cloud Computing in the Telemedicine.
2) All the articles were published in English.
3) All articles can be accessed in full (full PDF).
4) Articles published between 2013-2023.

Of the 12 articles, the author decided to focus on those related to the use of Cloud Computing in Telemedicine. To find articles that discuss Cloud Computing in Telemedicine, the author screened by reading the titles and abstracts of 12 articles, so that 10 articles that discussed Cloud Computing were found in Telemedicine.

F. Data Analysis

At this stage, the data collected will be analyzed to answer each of the predetermined research questions.

RESULTS AND DISCUSSION

A. Search Process Results

The search process was conducted at an early stage and resulted in 16

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studies. Furthermore, 16 studies carried out several screening stages to determine the relevant literature on the topic of research so that the final results were obtained for as many as 10 studies. Ten studies were selected based on the predetermined criteria. The search results are shown in Figure 2:

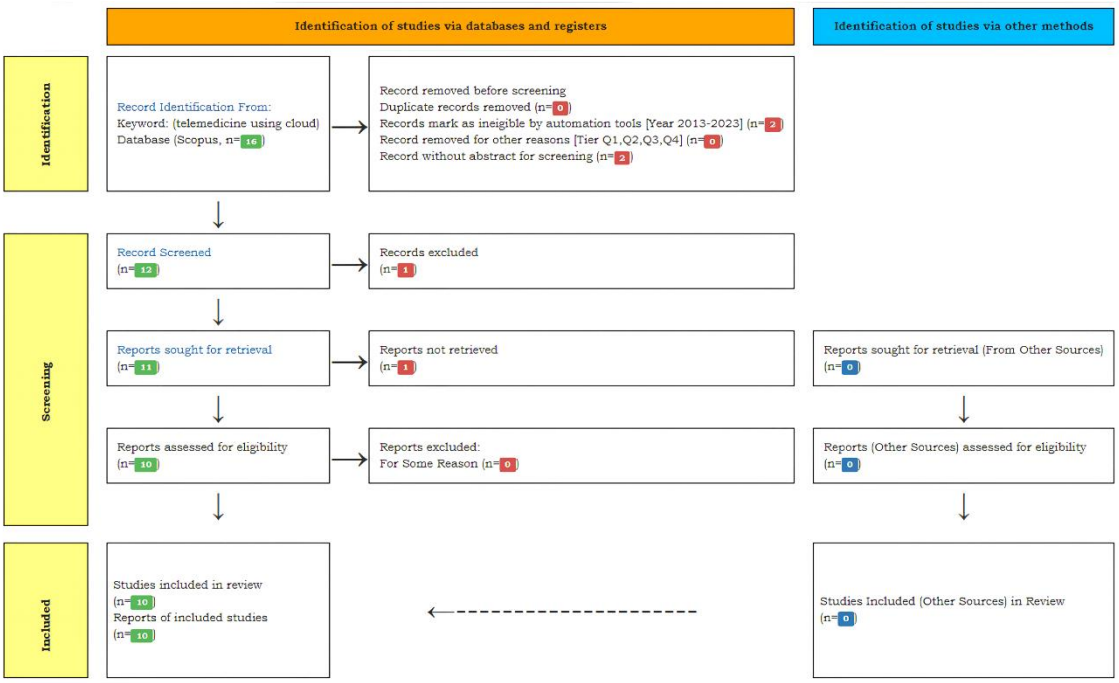

Fig.2. PRISMA guidelines from WATASE

B. Keyword Search, Criteria and Limitation

In accordance with the keyword "Telemedicine Using Cloud," and the selected year, i.e., 2013-2023, the search results obtained were 16 research articles, with the distribution of the year of publication and the number of articles according to the year of publication as follows:

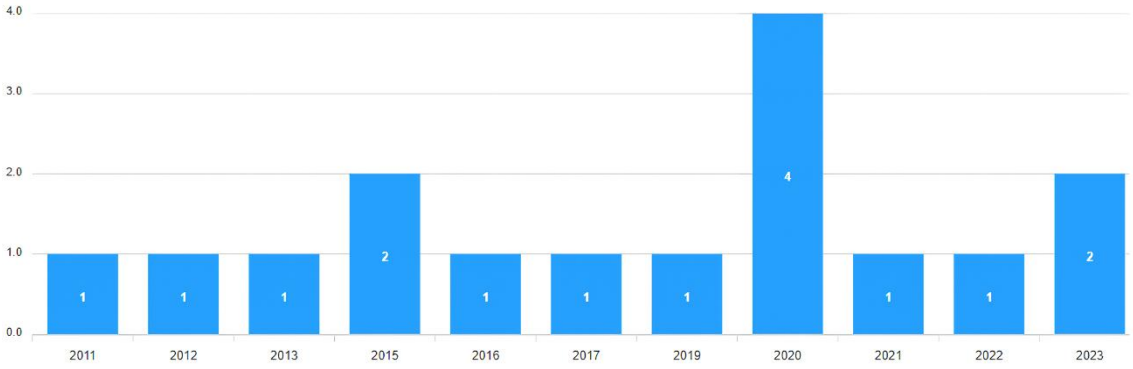

Fig.3. The number of articles according to the year of publication from WATASE

C. Quartile

Here, article filtering was performed based on quartiles and years of publication.

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No	Title	Year	Count	Cit	Journal Rank	Int	Link
1	A Deep-Learning-Based Collaborative Edge–Cloud Telemedicine System for Retinopathy of Prematurity, *Sensors*	2023	1	0	Q1		View
2	Telemedicine for enhancing positive airway pressure compliance in obstructive sleep apnea: Are we on cloud nine yet?, *Lung India*	2023	1	0	Q3		View
3	Cloud Robotic for Development of Smart Telemedicine, *Journal of Biomedical Physics and Engineering*	2022	1	0	Q3		View
4	Opportunities in the cloud or pie in the sky? Current status and future perspectives of telemedicine in nephrology, *CKJ: Clinical Kidney Journal*	2021	1	18	Q1	✓	View
5	Cloud-based secure telemedicine information system using crypto-biometric techniques, *EAI Endorsed Transactions on Pervasive Health and Technology*	2020	1	3	Q3	✓	View
6	Exploring publish/subscribe, multilevel cloud elasticity, and data compression in telemedicine, *Computer Methods and Programs in Biomedicine*	2020	1	5	Q1	✓	View
7	Implementation of a cloud-based referral platform in ophthalmology: Making telemedicine services a reality in eye care, *British Journal of Ophthalmology*	2020	1	49	Q1	✓	View
8	Multi-user certificateless public key encryption with conjunctive keyword search for cloud-based telemedicine, *Journal of Information Security and Applications*	2020	1	9	Q1	✓	View
9	Revolutionizing healthcare with IoT and cognitive, cloud-based telemedicine, *Acta Polytechnica Hungarica*	2019	1	24	Q2		View
10	Clustering-based compression connected to cloud databases in telemedicine and long-term care applications, *Telematics and Informatics*	2017	1	21	Q1	✓	View
11	A proof-of-concept evaluation of a cloud-based store-and-forward telemedicine app for screening for oral diseases, *Journal of Telemedicine and Telecare*	2016	1	36	Q1	✓	View
12	Cloud and traditional videoconferencing technology for telemedicine and distance learning, *Telemedicine Journal and e-Health*	2015	1	9	Q1	✓	View
13	Telemedicine in the cloud era: Prospects and challenges, *IEEE Pervasive Computing*	2015	1	63	Q1	✓	View
14	Practising cloud-based telemedicine in developing countries, *International Journal of Electronic Healthcare*	2013	1	6	Q4	✓	View
15	A cloud computing based 12-lead ECG telemedicine service, *BMC Medical Informatics and Decision Making*	2012	1	88	Q1		View
16	Modeling emergency and telemedicine heath support system: A service oriented architecture approach using cloud computing, *International Journal of E-Health and Medical Communications*	2011	1	13	Q3		View

Fig.4. Article filtering based on quartiles and years of publication using WATASE

After data selection, 10 articles met the inclusion criteria. At this stage, 10 data points or articles were analyzed to obtain answers to each predetermined research question. From the articles obtained, several ideas or topics were discussed regarding Cloud Computing in the field of telemedicine, including the following.

1. The role of Cloud Computing in the transfer process of Telemedicine-based Medical Image.
2. Digital image compression techniques from Telemedicine with the help of the role of Cloud Computing.
3. Security and Safety from Telemedicine integrated into Cloud Computing.

The following is an explanation of each topic:

1. The role of Cloud Computing in the transfer process of Telemedicine-based Medical Image

In telemedicine, doctors and healthcare workers use technology to provide medical care remotely, because being far away is an important concern. Creating telemedicine solutions is difficult because of insufficient computer power and the fact that the current network cannot handle large amounts of data. One common way this type of service is used is when teams of specialists work together remotely to diagnose and treat an illness. They need to share images instantly over the internet. Medical imaging is very important in telemedicine because it helps doctors to make accurate diagnoses[3].

Many challenges must be overcome to fully utilize the potential of big data in healthcare. Electronic Health Records (EHRs) and the limited processing abilities of mobile medical devices. Additionally, increasing public awareness and education regarding telemedicine can help individuals to understand its benefits and feel more comfortable using these services. This emerging field is making healthcare more accessible and affordable to individuals and communities. Cloud-based telemedicine offers convenient and high-quality healthcare through the internet. This is a dynamic, scalable, and pay-as-you-go feature. This means that users can easily access the service, grow up with their needs, and pay only for what they use. Using cloud-based telemedicine also means that users do not have to worry about maintaining equipment[11].

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A cloud-based Picture Archiving and Communication System (PACS) could store medical images online and offer services like "PACS-as-a-Service" or constant availability for radiology purposes. A simple prototype was designed to demonstrate the secure exchange of pictures between a user and a designated server using Microsoft Azure. A DICOM-compliant bridge was created to facilitate the sharing of DICOM services between healthcare institutions. This allows for efficient sharing of medical imaging services in different places or organizations. Making the transfer of big image files between PACS and image analysis servers more seamless[12].

2. Digital image compression techniques from Telemedicine with the help of the role of Cloud Computing

In the past, hospitals and medical institutions collected many medical images using different methods, such as MRI, X-ray, Ultrasound, CT, PET, and Digital Fluorography. The most important aspect of information and communication technology is ensuring that medical images remain intact when they are sent. The goal of image compression is to make image files smaller and cheaper to send while maintaining good quality and ensuring that medical images can be transmitted quickly. Compression is used to eliminate repetitive information.

There are three main methods in which images can be repeated or duplicated[3]:

1. Unnecessary or repetitive coding.
2. Repeat unnecessary information between neighboring pixels.
3. Psycho-visual redundancy means using extra information that the human eye usually does not notice.

The compression of medical images is important because it allows the images to be sent quickly over a smaller internet connection and with good quality in distant places[13]. Collaboration among teams of experts may be challenging when they are in different areas. This is particularly true when many medical images need to be shared. To solve this problem, PS2DICOM, a model that helps distant specialists work together better in a study, by sharing medical images and related information. The only thing that is different from other similar works is that PS2DICOM uses a cloud-based system that allows information to be published and subscribed to, and it also has advanced features, such as managing multiple levels of cloud storage and reducing data size as needed. These methods allow specialists to communicate and work together in real-time for therapeutic studies[3].

3. Security and Safety from Telemedicine integrated into Cloud Computing

Medical expertise, and information technology to provide remote healthcare services. It allows patients to consult with doctors and specialists through video calls, phone calls, or text messaging, eliminating the need for in-person visits. The system also enables medical professionals to remotely monitor patients' vital signs, review medical records, and provide diagnoses and prescriptions. It is a convenient and efficient way to receive healthcare without physically visiting a healthcare facility[14].

Cloud systems are Internet-based and allow users to access their files and applications from any device with an Internet connection. Traditional systems, however, are usually based on physical servers located on-site and require the use

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of specific devices to access files and applications. A major advantage of cloud systems is their flexibility and scalability. With cloud systems, users can easily modify their storage and computing resources based on their requirements. In contrast, traditional systems often require additional hardware and software upgrades to accommodate increased demand. Another advantage of cloud systems is accessibility. Users can access their files and applications anywhere and at any time if they have an internet connection. Traditional systems, however, often limit access to specific devices or locations. Cloud systems also tend to be more cost effective for many businesses. With cloud services, companies do not need to invest in expensive hardware or maintenance costs. Instead, they can pay for the services they require on a subscription basis. Traditional systems often require upfront investments in hardware and software as well as ongoing maintenance costs[2].

However, there are also some disadvantages to using cloud systems. Security is a major concern because cloud systems store data on remote servers. Although cloud providers often have robust security measures in place, there is still a risk of unauthorized access or data breaches. Ultimately, the choice between cloud and traditional systems depends on the specific needs and preferences of each user or organization. Cloud systems offer flexibility, accessibility, and cost-effectiveness; however, they also pose security risks. Traditional systems may provide more control and security, but often require more investment and limited accessibility. Many security systems use similar methods to verify people's identities. Encryption and password protection are methods used to add extra security to information. Traditional systems may need more measures in place to achieve this to scale to follow the rules of the institution's network security[2].

One way to authenticate is by providing a username and password, while fingerprint scanning or facial recognition are also viable methods. Authentication ensures that only authorized individuals can access the system and its resources, which helps to protect against unauthorized access and security breaches.

A system that collects and processes information for telemedicine purposes. Data outsourcing means hiring another company or organization to handle and take care of data needs will encounter major risks in terms of safety and confidentiality. To ensure that the data are safe and to make it easier to search for information[11] developed a new method called mCLPECK. This tool allows one to search for multiple keywords simultaneously and is useful for sending messages to multiple recipients. This is a story or situation attack that protects the users' personal information. The keyword attacks chosen and the study of how well they work show that mCLPECK is cheaper than other similar programs or plans to use for communication and calculations[11].

To ensure privacy, it is essential to establish a safeguard that restricts unauthorized access to patient images. Ensuring the protection of data requires the implementation of specific strategies, including the encryption of all Internet-transferred information using SSL. Furthermore, access to the system should be limited to authorized individuals[15].

CONCLUSION

The integration of cloud computing in telemedicine has paved the way for

significant advancements in medical image transfer, compression, security, and safety. Cloud-based telemedicine solutions offer scalability, accessibility, and cost-effectiveness, enabling remote healthcare delivery and collaboration among specialists. Medical image compression plays a crucial role in telemedicine by reducing the size of image files while maintaining diagnostic quality. Various compression techniques, such as eliminating repetitive coding, removing unnecessary information between pixels, and leveraging psycho-visual redundancy, help transmit medical images quickly over limited internet connections. Additionally, cloud-based systems facilitate the sharing of medical images among healthcare institutions, allowing efficient image analysis and diagnosis across different locations. Ensuring the security and safety of patient data in telemedicine systems integrated with cloud computing is of utmost importance. Cloud-based systems provide flexible access, scalability, and cost-effectiveness, but they also introduce security concerns. Robust security measures, such as encryption, access control, authentication protocols, and compliance with regulatory standards like HIPAA, are crucial for protecting patient privacy and preventing unauthorized access or data breaches. Innovative approaches like mCLPECK, a tool for secure communication and data searching, enhance privacy and protect personal information. In conclusion, the integration of cloud computing in telemedicine offers immense potential for remote healthcare delivery. Medical image transfer, compression, security, and safety are critical components of this paradigm. By leveraging cloud-based solutions and implementing robust security measures, telemedicine can overcome geographical barriers, enhance accessibility, and ensure the efficient and secure transmission of medical images, ultimately leading to improved healthcare outcomes for patients and healthcare professionals alike.

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