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Cloud computing and its interdisciplinary approach: A bibliometric study of the convergence with artificial intelligence and big data

Computación en la nube y su enfoque interdisciplinario: un estudio bibliométrico de la convergencia con la inteligencia artificial y el big data

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ABSTRACT

Research trends in cloud computing and its main interdisciplinary convergences with artificial intelligence and big data were identified using a bibliometric approach. Despite various bibliometric studies addressing the topic from different perspectives, no recent publications on cloud computing in this decade were found in Scopus. The field has experienced significant growth in the past ten years and has a high scientific impact, with a notable average number of citations per document. China and India are the leading contributors in this domain. The main characteristics of cloud computing studies in Scopus highlight its convergence with artificial intelligence and big data, reflected in systematic reviews and key scientific contributions. Term co-occurrence mapping revealed widely discussed topics such as cloud computing environments, cloud security, digital storage, and cryptography. More recently, Edge Computing has gained attention, with applications in various network environments.

Keywords: Artificial intelligence, big data, bibliometrics, cloud computing, Internet of Things, literature review

RESUMEN

Se identificaron las tendencias de investigación en computación en la nube y sus principales convergencias interdisciplinarias con inteligencia artificial y big data mediante un enfoque bibliométrico. Aunque diversos estudios han abordado el tema desde distintas perspectivas, no se encontraron publicaciones recientes en Scopus durante esta década. El campo ha experimentado un crecimiento significativo en los últimos diez años y tiene un alto impacto científico, con un notable promedio de citas por documento. China e India son los principales contribuyentes en este ámbito. Las características principales de los estudios sobre computación en la nube en Scopus resaltan su convergencia con inteligencia artificial y big data, evidenciada en revisiones sistemáticas y contribuciones científicas clave. El mapeo de co-ocurrencia de términos reveló temas ampliamente discutidos, como entornos de computación en la nube, seguridad en la nube, almacenamiento digital y criptografía. Más recientemente, la computación en el borde (Edge Computing) ha ganado relevancia, con aplicaciones en diversos entornos de red.

Palabras clave: Inteligencia artificial, big data, bibliometría, computación en la nube, Internet de las cosas, revisión de literatura

1. INTRODUCTION

Cloud computing has transformed how organizations and individuals' access, store, and process information, becoming a key pillar of the digital transformation of recent decades. According to Armbrust et al. (2010), cloud computing provides "a model for enabling ubiquitous, convenient, on-demand access to a shared pool of configurable computing resources" (p. 1). This paradigm has optimized technological infrastructure and encouraged convergence with emerging disciplines, such as artificial intelligence (AI) and big data, creating an unprecedented interdisciplinary impact.

Integrating cloud computing with AI has facilitated the development of more efficient and scalable systems capable of processing large volumes of data in real time. As Mohanty et al. (2020) note, "the cloud provides the ideal environment for implementing AI models, as it offers flexible and inexpensive computational resources for training and deploying complex algorithms" (p. 45). Conversely, big data has found an optimal platform in the cloud for storing and analyzing massive datasets, leading to advancements in fields such as data science, personalized medicine, and business management (Hashem et al., 2015; Ausejo Sánchez et al., 2024).

This bibliometric study investigates the intersection of cloud computing, AI, and big data. It analyzes research trends, influential authors, leading institutions, and emerging topics within this interdisciplinary field. By conducting a quantitative analysis of scientific publications, the goal is to determine how these technologies have developed together and their impact on academic literature. As Zupic & Čater (2015) state, "bibliometric studies provide a systematic and objective view of the structure and dynamics of a research field, allowing the identification of key patterns and trends" (p. 429).

In this context, the present work contributes to understanding the current state of research in cloud computing and its interaction with AI and big data. It also offers perspectives for future research and practical applications in this interdisciplinary field.

Cloud computing is a technological model that provides on-demand access to shared computing resources, including servers, storage, applications, and services, over the Internet. It is defined as "a paradigm that enables ubiquitous, convenient, on-demand access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or interaction with the service provider" (Mell & Grance, 2011, p. 2).

The primary models are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). IaaS provides essential infrastructure resources, PaaS offers an environment for developing and deploying applications, and SaaS allows users to access applications hosted in the cloud (Armbrust et al., 2010, p. 51). Scalability and elasticity are key features of cloud computing, adjusting resources based on demand. In the cloud, scalability enables organizations to increase or decrease their computing resources dynamically, ensuring optimal performance and efficient resource use (Buyya et al., 2013, p. 6).

It is related to virtualization, a fundamental technology that enables the creation of virtual versions of physical resources, such as servers, storage, and networks, and forms its foundation. According to Smith and Nair (2005, p. 32), it facilitates the creation of virtual environments that can run multiple operating systems and applications on a single physical hardware unit. Another essential

element is security, as data and applications are stored and managed on remote servers. As Jansen and Grance (2011, p. 1) state, this includes protecting the data, applications, and infrastructures linked to cloud services, such as identity management, data encryption, and defense against cyber threats. This phenomenon has enabled the processing and analysis of large volumes of data by offering a scalable infrastructure and advanced tools (Hashem et al., 2015; Andrade-Girón et al., 2024).

It also creates an ideal environment for developing and deploying AI applications due to its capacity to manage large volumes of data and provide computational power. Cloud computing has democratized access to AI by allowing organizations to implement machine learning models without the need to invest in costly local infrastructure" (Mohanty et al., 2020, p. 45). Its primary advantage is the reduction of infrastructure costs, scalability on demand, and the ability to access resources from anywhere at any time" (Marston et al., 2011, p. 176).

Bibliometric background related to cloud computing

Abaee et al. (2024) explore the integration of the Internet of Things (IoT) and cloud computing about the Sustainable Development Goals (SDGs) and Industry 4.0. By employing bibliometric techniques, they map scientific output, identify trends and collaborations, and highlight these technologies' crucial role in industrial sustainability, especially concerning energy efficiency, resource management, and emissions reduction. Similarly, Ampofo et al. (2024) presents a historical analysis of cloud computing's application within organizational structures from 1800 to 2022. Utilizing bibliometric data, they reveal patterns of adoption and their impact on operational efficiency. Their findings demonstrate that cloud computing has transformed organizations by providing flexibility, scalability, and global collaboration.

Similarly, Cai et al. (2015) perform a bibliometric analysis of cloud computing research up to 2015. They identify this field's most influential authors, institutions, and topics, highlighting key areas such as security, virtualization, and scalability. Their study emphasizes the rapid growth of research in this domain and its impact on the technology industry. In contrast, Chen (2022) explores research on green buildings through bibliometric analysis and cloud computing. He identifies key trends and topics related to sustainability and energy efficiency using big data techniques. His findings underscore the importance of cloud computing for data analysis in sustainable construction.

In their study, Durgut et al. (2023) examine the connection between cloud computing and business intelligence (BI). They utilize bibliometric tools to assess scientific production and collaborations in this domain. Their findings indicate a growing incorporation of cloud technology in BI solutions, especially in data analysis and decision-making. Regarding energy optimization, Dutta (2023) investigates research in this area through cloud computing. He uncovers key trends and authors through bibliometric analysis, emphasizing the cloud's significance in effective energy management within complex systems and its impact on energy sustainability.

From a broader perspective, Fortiș & Fortiș (2021) provide a comprehensive overview of research projects in cloud computing. Using bibliometric techniques, they analyze publications and collaborations, identifying security, scalability, and business applications as primary areas of interest. Their work thoroughly reviews the state of research in this domain. Conversely, Garg et al. (2024) focus on emerging security trends in cloud computing. Their findings emphasize the

significance of cybersecurity, data encryption, and identity management, presenting an updated view of the challenges and solutions within this field. In the same vein of software security and quality, Garg et al. (2024) investigate research related to testing and validation in cloud computing environments. Through a bibliometric analysis, they identify trends and challenges, highlighting test automation and software quality as critical areas. Their results underscore the necessity of testing for the successful adoption of cloud computing.

In the agricultural field, Jombo & Abd Elbasit (2023) explore the application of cloud computing to manage data from remote sensors. Using bibliometric techniques, they map the scientific production in this sector and show how the cloud is transforming modern agriculture by facilitating data-based decision-making. On the other hand, Wang et al. (2024) investigate the integration of AI and cloud computing in the construction industry. After combining bibliometric analysis and systematic review, they identify its applications in project management, design, and sustainability. Their results reveal that these technologies are revolutionizing the construction industry. Finally, Yu et al. (2018) presents a study analyzing research in cloud computing up to 2018. They identify trends and collaborations in the field and highlight the exponential growth of research in areas such as security and scalability. Their findings provide a solid basis for understanding the evolution of this field.

These studies highlight the significance of bibliometric analyses in examining trends, collaborations, and emerging topics in cloud computing and related fields. Each offers valuable insights from historical, thematic, or practical perspectives and utilizes robust methodologies to chart scientific knowledge.

In this research, we identify the primary characteristics of the published literature on cloud computing, the trends in this area, and its interdisciplinary links with AI and big data.

2. MATERIALS AND METHODS

The study presents a quantitative approach based on a non-experimental design. It utilizes a sample of scientific production registered in Scopus over the last 10 years (2015-2024). Bibliometric techniques are employed to search, process, and represent quantitative information. We also utilize visualization tools such as Bibliometrix and its Biblioshiny library, which facilitates the generation of specific primary reports and multivariate representations (Wattanasiri et al., 2024).

The search strategy combines the keywords of the object of study with a time frame from 2015 to 2024. Additionally, the types of documents were specified to obtain citable documents from the entire sample registered in this database. The search equation was: TITLE (cloud AND computing*) AND PUBYEAR > 2014 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE , “cp”) OR LIMIT-TO (DOCTYPE , “ar”) OR LIMIT-TO (DOCTYPE , “ch”) OR LIMIT-TO (DOCTYPE , “re”) OR LIMIT-TO (DOCTYPE , “cr”)) AND (LIMIT-TO (SUBJAREA , “ENGI”) OR LIMIT-TO (SUBJAREA , “COMP”)).

The productivity indicators of authors were calculated, Lotka's law was applied, and the primary sources or resources that publish the most on the subject were identified. Additionally, keyword density maps and a co-occurrence network of keywords over time were visualized to pinpoint the main research edges or axes and their trends.

3. RESULTS AND DISCUSSION

Table 1 presents the primary indicators of scientific production in the field of cloud computing recorded in Scopus over the past decade. A total of 4,833 sources of information were identified that published 19,122 works on the topic, mainly categorized as journals, book chapters, conference papers, and review articles. Given the total number of documents retrieved, the overall growth in the literature (0.41%) is considered low.

Table 1. Primary indicators of scientific production on cloud computing recorded in Scopus

Time frame	2015-2024
Publications	4833
Papers	19122
Annual growth rate	0.41
Age of documents	5.45
Average citations per document	13.77
Authors	30526
Transient authors	1331
Total, co-authorship rate	3.26
% international co-authorship	17.75
Articles	8251
Book chapters	1159
Conference proceedings	379
Event papers	9014
Review articles	316

As observed, the age of the documents published on this subject is short. In other words, they age quickly, typically within about 5 years. This topic has a high volume of scientific production, leading to significant documentary flow and indicating an evolving theme. Another point worth mentioning is the collaborative nature of scientific production, as, on average, 3.26 authors contribute. However, only 18% of the documents demonstrate international co-authorship, implying that the research groups largely maintain a specific perspective within a country or region.

The evolution of the number of works published during this period does not display significant variations over the analyzed decade. Generally, more than 1,700 documents are published yearly, and the changes from one year to the next are not substantial; instead, there is a consistent flow of documents. This accounts for the low total growth rate of 0.41% (Figure 1).

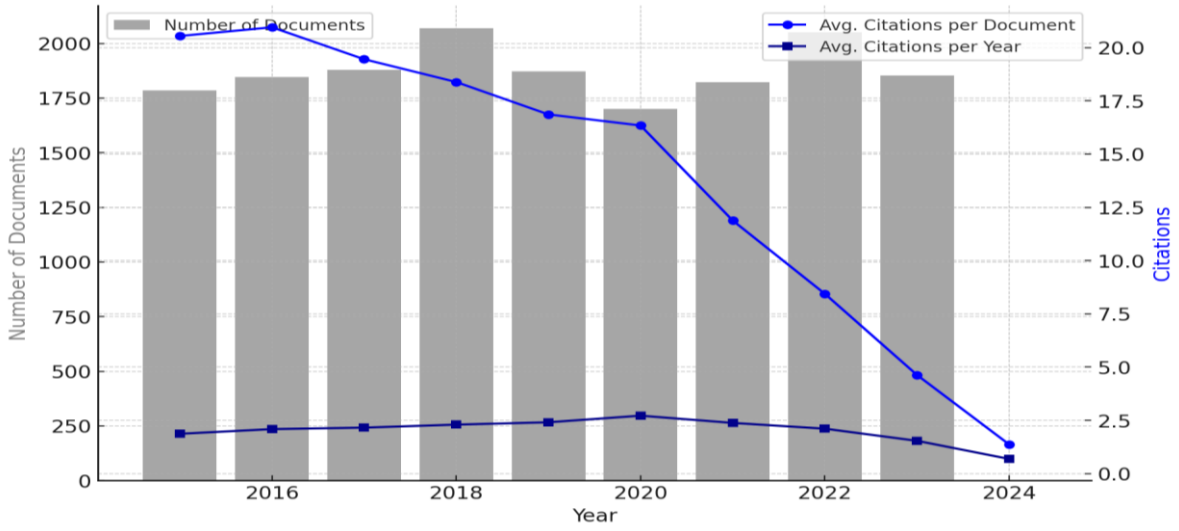

Figure 1. Evolution of the number of published works and their impact received in Scopus

Another noteworthy aspect is the more significant decrease from 2020 onward, which may be linked to changes in citation practices, the quality of documents, or the influence of global events like the COVID-19 pandemic. Conversely, despite the drop in the average number of citations per document, this rate increased until 2020 (2.72), suggesting that the published documents remained relevant and frequently cited during that period. Starting in 2021, this indicator begins to decline, reaching its lowest point in 2024 (0.69), which might imply reduce visibility or impact of documents published in recent years.

The key observations from this data indicate a shift in citation dynamics, which may be attributed to two fundamental reasons: a change in research practices, such as increased thematic specialization or reduced interdisciplinarity, which narrows the scope of citations, or a rise in the number of documents published, which diminishes the citations per document.

Another aspect to consider is the impact of external events, such as the COVID-19 pandemic, which affected academic production, collaboration dynamics, and citations. On the positive side, the average number of citations per year remained relatively stable until 2020, suggesting that the papers published in that period remained relevant.

The authors' productivity was analyzed using Lotka's Law, a bibliometric principle that explains the distribution of authors' productivity within a scientific field. Lotka's Law states that the number of authors producing \(n \) documents is inversely proportional to \(n^2 \). In other words, most authors publish only a few documents, while a small number publish a large volume. The distribution of authors by the number of papers written shows that the vast majority (72.2%) have written a single document, while 13.7% have written two (Figure 2). As the number of documents increases, the number of authors decreases dramatically. For example, only 0.052% of authors have written three documents, and this proportion continues to decline to values close to zero for authors with more than twenty documents.

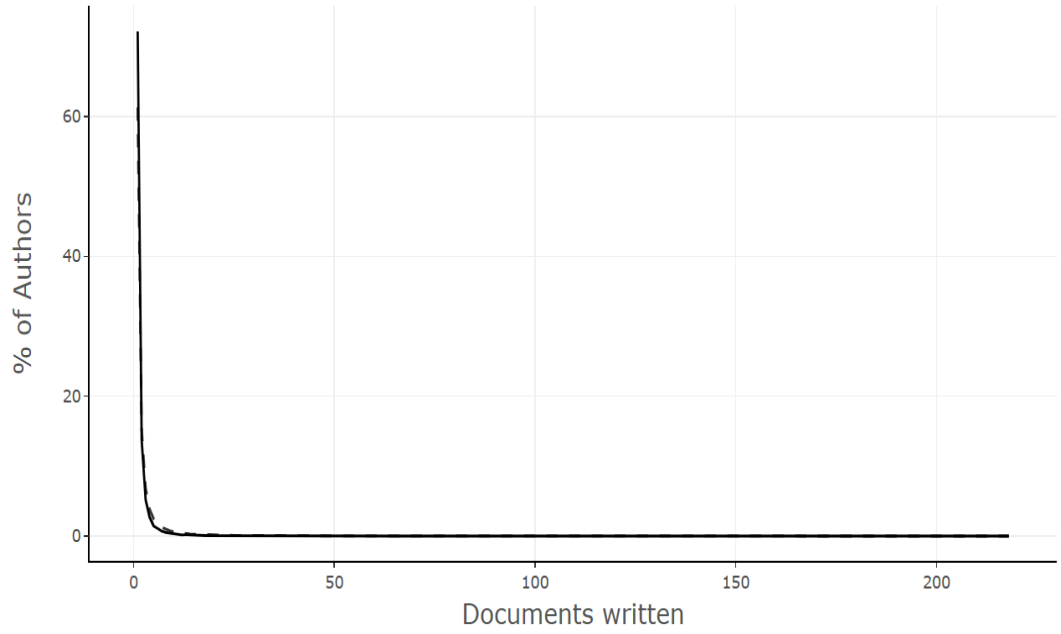

Figure 2. Representation of Lotka's Law in the productivity of authors on cloud computing

Regarding compliance with Lotka's Law, the data indicate that the distribution closely aligns with the law, although some deviations are typical in empirical studies. Additionally, there is a long tail

in the distribution, where one author has produced 218 documents while most authors demonstrate low productivity (1 or 2 documents). A few authors have exceeded 100 documents. Although these exceptional authors form a very small fraction of the total, their contributions are significant in terms of production volume. Essentially, the observed distribution confirms that scientific production is highly concentrated among a few authors, while most authors generate only a few documents. This may be attributed to factors such as specialization, collaboration within research networks, or the availability of resources.

If we plot the number of documents written (n) on the x axis and the proportion of authors on the y axis, we obtain a curve that declines rapidly, indicating an asymmetric distribution with a long tail to the right. This is characteristic of distributions that follow Lotka's Law. The data provided largely follow Lotka's Law, which confirms that scientific productivity is unevenly distributed among authors. Many authors (72.2%) are “sole contributors” (writers of a single document), while a small group of authors are highly productive. This pattern is typical in the scientific literature and reflects research's competitive and collaborative nature.

Figure 3 shows the contribution of countries to research on cloud computing. China is the leader, followed by India. These two countries contribute the most experiences and solutions in this field.

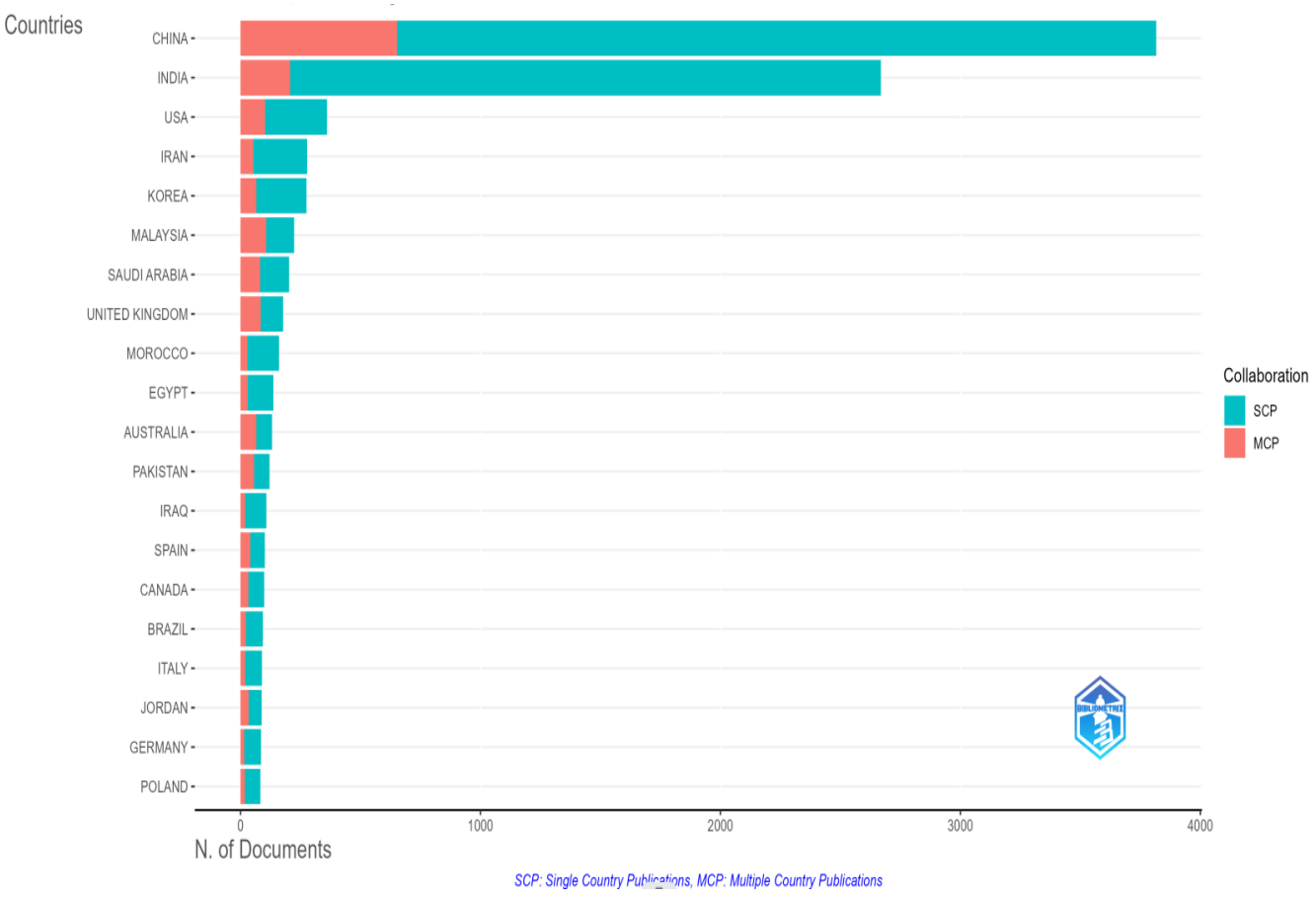

Figure 3. Primary and secondary scientific collaboration by country

China and India are at the forefront of cloud computing research, fueled by their economic growth, large populations, investments in education and technology, and supportive government policies. Both nations have cultivated robust ecosystems that integrate talent, infrastructure, and state backing, enabling them to play a vital role in the global advancement of this technology. They have established themselves as leaders through their swift economic growth, considerable populations,

and substantial investments in education and technology. They boast vast digital markets that demand cloud solutions, spurred by the digitization of their economies and the rise of local tech firms such as Alibaba, Tencent, and Tata Consultancy Services. Additionally, they have emphasized training talent in STEM fields and have enacted government policies that foster innovation, including the "Made in China 2025" plan and the "Digital India" initiative.

Collaboration between industry and academia, along with the development of world-class technological infrastructure, has enabled China and India to excel in this field. China has constructed a network of data centers and fostered the use of indigenous technologies, while India has positioned itself as a global hub for IT services outsourcing. These factors, coupled with their adaptability to the global market's demands, have made both countries key players in cloud computing research and applications.

A close analysis of articles published in the past year by Chinese authors reveals 18 works that are review articles or reference bibliographic reviews on cloud computing. The reviewed articles cover various applications and challenges of cloud computing in China and highlight its impact in the logistics, energy management, manufacturing, and education. For instance, Alnaimat et al. (2024) explore implementing cloud technology in digital accounting systems for logistics companies. Rajagopalan et al. (2024) analyze the synergy between the IoT and cloud computing to optimize energy distribution systems. Technical advancements are also discussed, including the use of deep neural networks for analyzing educational data (Liu, 2024) and the application of blockchain for secure data storage (Zhang et al., 2024).

On the other hand, several studies focus on optimization and security in cloud environments. Wang et al. (2024) examine the use of adversarial generative networks to improve security, while Zhou et al. (2024) review reinforcement learning methods for resource scheduling. These works reflect China's leadership in cloud computing research, highlighting its focus on technological innovation, sustainability, and practical application in various economic and social sectors.

These review papers demonstrate the convergence of AI and big data, demonstrating how these technologies are integrated to improve efficiency, security, and decision-making in the logistics, manufacturing, education, and energy management sectors. This synergy drives innovation, allows the management of large volumes of data, and automates complex processes, consolidating the cloud as a fundamental pillar in the digital age.

Recent topics in systematic reviews encompass regenerative networks, effort learning, deep neural networks, support vector machines (SVM), serverless computing, big data-based decision-making in businesses, and collaborative computing among edge, cloud, and endpoints. Additionally, the quality of experience (QoE) in the cloud, the optimization of cloud services for users, and the storage and secure transmission of data in blockchain-based cloud systems to ensure information integrity and security are fundamental.

Figure 4 offers a more detailed perspective, showing the keyword density in papers published in Scopus over the last decade. Notable areas of density are identified in relation to cryptography, the IoT, network security, digital storage, cloud computing environments, and energy utilization.

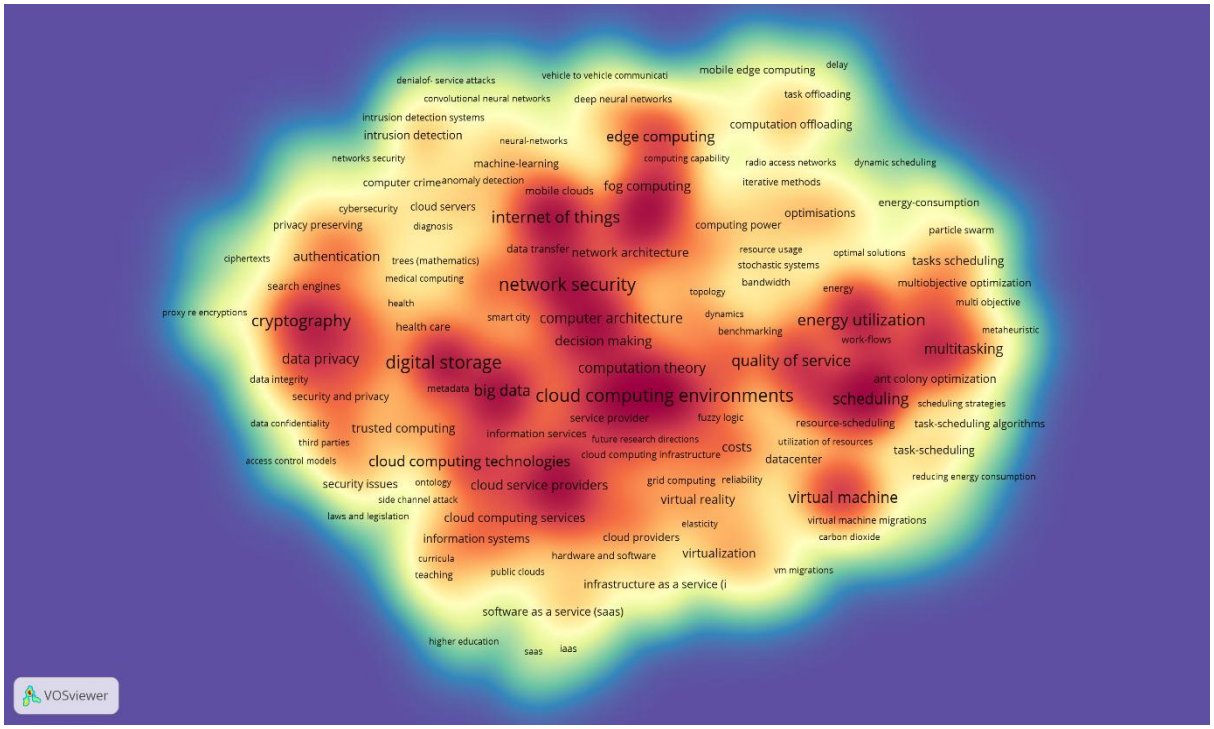

Figure 4. Density map of keywords in publications on cloud computing (Scopus 2015-2024). Keywords with a frequency greater than 50

Cryptography is a fundamental discipline for information security, particularly in the IoT and cloud computing context. In the IoT, where millions of devices are interconnected, cryptography ensures that the data transmitted between these devices is protected against unauthorized access and manipulation. Techniques such as symmetric and asymmetric encryption and authentication protocols ensure the confidentiality, integrity, and authenticity of the information. Furthermore, in cloud computing environments, cryptography plays a crucial role in safeguarding data in storage and transit, allowing users to have confidence in the security of their applications and services in the cloud.

Network security and digital storage are fundamental aspects of the cloud computing era. With the increasing volume of data generated by IoT devices and cloud applications, it is essential to implement robust measures to protect networks against cyberattacks, including intrusions, malware, and denial of service. Digital storage solutions, such as distributed storage systems and encrypted databases, allow for the secure and efficient management of large volumes of information. Additionally, while cloud computing offers advantages like scalability and accessibility, it also necessitates advanced security strategies, including network segmentation, continuous monitoring, and the implementation of next-generation firewalls.

Energy usage in cloud computing is becoming an increasingly important issue due to the environmental and economic impacts of data center energy consumption. Cloud service providers are adopting more efficient technologies, such as server virtualization and liquid cooling, to reduce energy usage. Additionally, renewable energy sources like solar and wind are being considered to power data centers sustainably. Optimizing energy consumption not only lowers operating costs but also helps to create a smaller carbon footprint, which aligns with global sustainability goals. In this context, green cloud computing is emerging as a priority for companies seeking to balance technological performance with environmental responsibility.

Cloud computing is intrinsically an interdisciplinary field, integrating knowledge from various areas to provide advanced technological solutions. For instance, its connection to cryptography and network security is vital for ensuring data protection in distributed environments. Cryptography offers the mathematical and algorithmic foundation for encrypting information, while network security employs protocols and tools to prevent intrusions and facilitate communication between devices. Additionally, digital storage gains from cloud computing by allowing efficient management of large volumes of data through techniques like replication and encryption to maintain its availability and confidentiality. This interplay among disciplines enables the creation of robust and scalable infrastructures that fulfill the needs of users and businesses.

On the other hand, cloud computing is also connected to the IoT and energy usage, highlighting its interdisciplinary nature. The IoT generates vast amounts of data that need processing and storage in the cloud, requiring efficient energy management solutions to reduce environmental impact. Optimizing energy consumption in data centers through methods like virtualization and the use of renewable energy exemplifies how cloud computing intersects with sustainability. Additionally, fields such as electrical engineering and environmental science play a role in developing more efficient systems, while AI and data analysis enable the prediction and adjustment of resource use in real time. This convergence of fields shows that cloud computing is not merely a technology, but an interdisciplinary ecosystem that fosters innovation across multiple sectors.

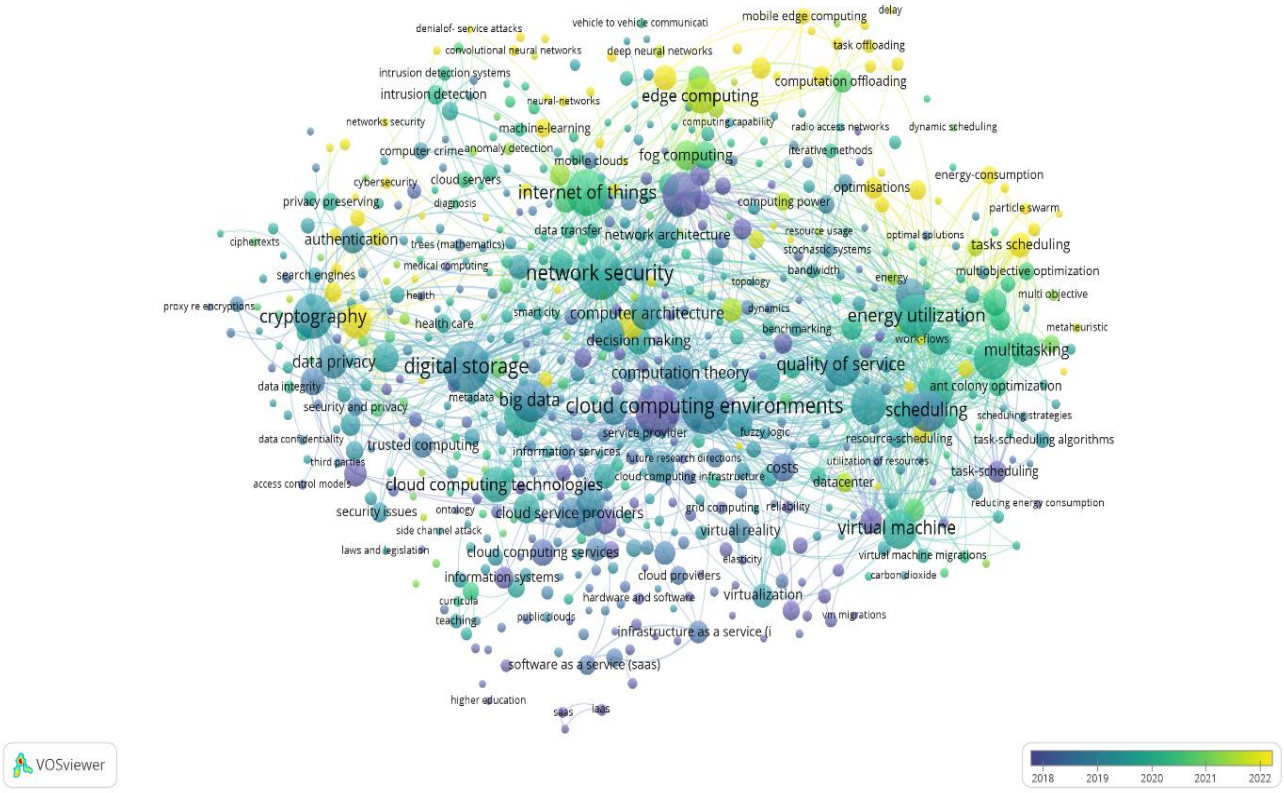

Figure 5. Evolution of the co-occurrence of keywords on cloud computing during 2015-2024

Figure 5 offers an alternative perspective on the thematic behavior and interdisciplinary focus of the study's subject. The color scale indicates that the more intense shades, like purple and green, are associated with works or research conducted before 2021 and dominate the visualization. In this context, the findings related to cloud computing environments, cloud security, digital storage,

and cryptography become more pronounced. These clusters are larger than others, including privacy, workflow, multitasking, quality of services, and computer architecture, which also stand out on the web.

The yellow clusters indicate more recent works and, to a lesser extent, are associated with works that reference terms like edge computing. In this context, it is a distributed computing paradigm that complements cloud computing by bringing data processing and application execution closer to the source of data generation, or the "edge" of the network, rather than depending solely on centralized data centers. While cloud computing centralizes storage and processing on remote servers, edge computing decentralizes these functions, enabling local devices or nearby nodes (such as routers, gateways, or IoT devices) to carry out real-time processing tasks.

This approach is especially valuable when latency, bandwidth, and privacy are crucial. For example, edge computing facilitates rapid decisions in IoT applications such as autonomous vehicles, smart factories, or healthcare systems without the need to send data to the cloud and wait for a response. However, edge computing does not replace cloud computing; it operates alongside it. The most critical data is processed locally (at the edge), while less urgent data or data needing deeper analysis is sent to the cloud for extensive storage and processing. This collaboration enhances performance, decreases network load, boosts energy efficiency, and promotes a more resilient and adaptable technological ecosystem.

Another recent term related to the co-occurrence of keywords is Mobile Edge Computing (MEC), also referred to as Multi-access Edge Computing. This is an evolution of the edge computing concept specifically applied to mobile networks. It represents architecture that enables processing, storage, and computing services to be located at the edge of the mobile network, which means close to end users and connected devices. This is accomplished by integrating servers and computing resources into the base stations of cellular networks, such as 5G towers, or into nearby access points.

The primary goal of MEC is to minimize latency, enhance efficiency, and deliver low-delay, high-capacity services for applications requiring real-time responses. This is especially crucial in scenarios such as augmented reality (AR), autonomous vehicles, cloud gaming, smart cities, and industrial IoT applications. For example, in an augmented reality context, MEC allows data to be processed locally at the network's edge, removing the necessity to transmit it to a distant data center, resulting in a smoother experience without delays.

Moreover, MEC utilizes 5G networks that offer greater bandwidth, reduced latency, and increased connection density. The synergy between MEC and 5G creates a landscape of innovative applications and services that require high performance and nearly instantaneous response times. In summary, Mobile Edge Computing is a vital element in the evolution of mobile networks, allowing for more distributed computing closer to users, improving customer experience, and unlocking new technological possibilities.

CONCLUSIONS

A bibliometric study of cloud computing and its interdisciplinary connection with AI and big data reveals exponential growth in scientific and technological output in these fields, emphasizing their significance in today's digital transformation. Bibliometrics helps identify trends, key authors,

leading institutions, and collaborative networks, demonstrating how cloud computing supports the advancement of AI and big data. The cloud offers the scalable infrastructure and processing power necessary to manage large volumes of data and execute complex AI algorithms, enhancing research and applications in the healthcare, industry, education, and finance sectors.

The interdisciplinary nature of cloud computing, AI, and big data is evident in innovative solutions that combine the cloud's distributed storage and processing capabilities, AI's predictive and analytical functions, and the effective management of large data sets. In data science, the cloud offers on-demand access to computational resources, enabling the training of machine learning models and real-time analysis of big data. Furthermore, integrating these technologies has led to advancements such as recommendation systems, process automation, and resource optimization, highlighting their cross-disciplinary influence.

Finally, the bibliometric study highlights the challenges and future opportunities associated with this technological convergence. These challenges include data security, privacy, and energy efficiency—areas that require further research to ensure the responsible and sustainable use of these technologies. Conversely, the opportunities highlight the expansion of applications in emerging fields such as edge computing, quantum computing, and advanced IoT, where the synergy between the cloud, AI, and big data will continue to drive innovation. In conclusion, this study emphasizes the importance of fostering interdisciplinary collaboration and ongoing research to maximize the potential of these technologies for the benefit of society.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest related to the development of the study.

AUTHORSHIP CONTRIBUTION

Conceptualization; Data curation; Formal analysis; Fund acquisition; Research; Software; Validation, Visualization; Writing - original draft; Writing - proofreading and editing: Marín-Rodríguez, W. J., Andrade-Girón, D. C., Susanibar-Ramírez, E. T., and Marcelo-Zuñiga, R.

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