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Cloud Computing and AI: Evolution, Emerging Trends and Future Directions

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Abstract: This study explores the cloud computing research area to deal with the intricate challenges of future computing. This bibliometric analysis assesses publishing patterns in the domains of AI and Cloud Computing. The tools commonly employed for conducting bibliometric analysis include VOS viewer and R studio. A total of 1234 pertinent papers were retrieved from the SCOPUS database by implementing different Boolean procedures. Bibliographic coupling has been performed to identify the key clusters that emphasize on the current technology that is essential for promoting efficiency and sustainability of cloud computing in the present scenario and near future.

Keywords: *Bibliometric analysis, Cloud Computing, Artificial Intelligence, Edge Computing*

1. Introduction

The concept of "cloud computing" has been extensively studied for the past twenty years, focusing on its definition and progress. Cloud computing is a result of extensive research in distributed systems, dating back to the development of the client-server model in 1958 [3]. Advancements in networking and distributed architectures propel cloud computing. Due to the widespread adoption of cloud computing, individuals and organisations from various sectors, such as academia, government, and business, have come to appreciate its value as a utility. The features of cloud computing, including flexible and measured access to shared computing resources, have enabled the development of innovative technologies and approaches that can address the needs of various emerging applications, such as those in science, healthcare, agriculture, smart city management, and traffic management. We are currently in the era of Cloud Computing (CC). It has gained significant recognition and respect in both industry and academia. Thanks to the convenience of CC, consumers no longer need to make large investments in IT infrastructure. Cloud Consumers (CCr's) have the option to utilise employee resources from the cloud, which is based on a pay-as-you-go model. This model provides elastic resource provisioning and allows for broad network access. The National Institute of Standards and Technology (NIST) has provided a definition for CC. As per NIST, CC is a model that enables seamless and convenient access to a network of computing resources. These resources can be easily provisioned and released with little effort or interaction with service providers [1]. CC has completely transformed the way consumers engage with software and IT infrastructure. The emergence of computing as the fifth utility has been made possible through CC adaptation [2]. Since its emergence, industry organisations, governmental institutions, and academia have fully embraced it. However, CC is not widely seen as a mature alternative to traditional computing models. Ongoing research is being conducted in various dimensions of this field.

This bibliometric analysis explores the current research landscape of cloud computing to tackle the complex challenges of future computing. In addition, experts from various international cloud computing research domains come together to analyse current research and suggest future research directions for academics, professionals, and researchers involved in the cloud computing field.

The Section 2 covers sampling and methodology, Section 3 presents the analysis of literature, Section 4 explores science mapping, Section 5 provides a discussion of the study, Section 6 offers detailed policy implications, and finally, Section 7 concludes the article.

2. Sampling and Methodology

Bibliometrics is a widely used technique for analysing and assessing primary collections, surveying publications, examining documents, and identifying scientific management libraries. Bibliometric studies provide the foundation for significant advancements in a particular field. It assists scholars in attaining numerous advantages.

2.1. Search Standards and Article Selections

The process of identifying relevant material starts by selecting keywords using Boolean logic operators such as 'or' and 'and' from the Scopus database. The search was conducted on 20 May 2024. The primary goal of

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generating keyword strings is to expand the range and include a variety of articles that are connected to digital education and financial literacy. We utilise these keyword phrases:

"cloud AND computing AND artificial AND Intelligence" or "sustainable AND development AND goals AND cloud AND computing" or "sustainable AND development AND goals AND industry 4.0" or "SDG AND industry 4.0 AND cloud AND computing" or "SDG AND AI"

The designated keywords directly encapsulate the relationship between cloud computing and AI and the initial outcome was (n = 10377). The search was narrowed down to a particular time period (2022-2024) and the literature resultedin (n = 4490). The cumulative publication of this field covered these subject areas(i) Computer Science and Management, (ii) Business Management and Accounting, the first subject grouping represents 44% of the total documents and the second subject category accounts for 56%, the total number of records was (n = 3239). After that narrowing down to publication type in research articles the remaining records were (n = 1372). Following that the search was refined to include only final-stage publications which resulted in the inclusion of (n = 1259). In the inclusion phase, only those records were kept which was published in the English language which resulted in the exclusion of (n = 25) records which concludes with (n = 1234) records eligible and included in this study.To accomplish this goal, all the necessary terms were included. The VOSviewer 1.6.18 software was selected for this phase due to its outstanding ability to visualise bibliometric data as seen in Fig. 2 and its accessibility as a free tool [19].

3. Bibliometric Visualisation

3.1. Main Information

Fig. 1. provides a concise overview of important bibliometric indicators derived from a comprehensive collection of literature on cloud computing and AI. Fig. 2 shows the thematic cluster analysis of this collection. The data was obtained from the Scopus database and encompasses the period from 2022 to 2024. The dataset consists of 1234 documents sourced from 430 different sources. These documents were written by 4242 authors, with an average of 4.35 co-authors per document. Additionally, 38.65% of the documents involved international collaboration. It is worth mentioning that 83 documents were written by a single author. The dataset reveals a significant annual decline of -33.86% in publication volume. The documents have an average age of 1.23 years and an average of 9.011 citations each. There are a total of 65279 references cited and 3549 distinct author keywords used, indicating a wide range of research that is relatively recent.

4. Science Mapping

4.1. Bibliographic Coupling

Cluster 1: Edge Computing and Federated Learning: Synergies for IoT and Cybersecurity

Seven articles make up the biggest cluster that emerged from bibliographic coupling; they all deal with edge computing, artificial intelligence, and federated learning as it relates to the Internet of Things (IoT) and cybersecurity. The most cited article in this cluster is by authors Ghimire and Rawat [6]. Examining new trends in federated learning to enhance cybersecurity is its principal goal. In particular, it zeroes in on uses that are within the scope of the Internet of Things (IoT). A separate study by Firouzi et al. [4] provides a detailed analysis of the paradigm of edge-fog-cloud computing. To achieve this, they provide a set of talks covering every important facet of paradigm-supporting technologies. This facilitates faster knowledge acquisition and opens the door to more thorough research. One notable survey article that explores the role of edge AI in solving different technical problems and UAV applications is by McEnroe et al. [11]. The key contributions are as follows: 1) Analyse how AI and edge AI can improve UAV systems' technical capabilities.2) Look into the major UAV applications where edge AI plays a role. 3) Analyse the possible problems with using edge AI in UAVs and suggest ways to fix them. While McEnroe et al. [11] presents an innovative survey piece that explores the role of edge AI in solving different technical problems and UAV applications, other studies stand out. The key contributions are as follows: 1) investigate how AI and edge AI can improve the technical capacities of UAV systems.2) Look into the major UAV applications where edge AI plays a role. 3) Analyse the possible problems with using edge AI in UAVs and suggest ways to fix them. Overall this cluster encompasses the realm of edge computing and AI for IoT and cybersecurity.

Cluster 2. Sustainable and Innovative Practices in Industry 4.0 for Manufacturing

Cluster 2 delves into the following topics: the development of environmentally friendly technologies, long-term sustainable growth, future predictions, the circular economy's performance, and the use of new technology for risk management within the context of Industry 4.0 in manufacturing. Lee et al. [9] presents the most cited study from this group, it details on how industrial robots (IRA) affect GTI in global manufacturing. According to the results of the endogenous and robustness tests, the IRA significantly improves GTI. The IRA also finances eco-friendly studies and policies, which helps green tech innovation. Depending on the sector and location, new environmentally friendly technologies may have varying effects on the uses of industrial robots. In addition, as part of Industry 4.0, industrial robots will encourage new

developments in environmentally friendly technologies.Based on the findings of Mukhuty et al. [12], the cluster investigates the human-related obstacles that impede the sustainable expansion of Industry 4.0 digital manufacturing. This study looks at how human resource management practices can help overcome these obstacles to enable the socially responsible development of Industry 4.0. Also, in the UK manufacturing sector, study by Rodríguez-Espíndola et al. [17] look at how regulations, market pressure, and requirements affect the behavioural intention to use new Industry 4.0 technologies for risk management.Taken together, these studies show how complex it is to attain the objectives of Industry 4.0 through the use of industrial robots, human resource strategies, and regulatory frameworks, all of which are essential to driving sustainable and innovative manufacturing practices.

Cluster 3: Industry 4.0 and 5.0: Sustainability and Innovation

Cluster 3 demonstrates the transformative impact of Industry 4.0 and 5.0 on agriculture and manufacturing. These industries are adopting modern technologies such as digital twins and zero-defect manufacturing (ZDM) to improve efficiency and sustainability. Leng et al. [10] aim to redefine Industry 5.0 by comparing its initial definition and features in the European Union with other perspectives. Their goal is to reconcile these different viewpoints and offer an in-depth knowledge of the flexibility of Industry 5.0. Simultaneously, Psarommatis et al. [15] clarify the ZDM strategy, providing a distinct and cohesive definition to establish a shared comprehension throughout the industry. Meanwhile, Kamble et al. [8] examine the concept of digital twins in sustainable manufacturing supply chains. They investigate how virtual and physical systems can be integrated using disruptive technologies. Their goals encompass evaluating the existing literature on digital twins, analysing different technological elements in the creation of digital twin frameworks, and identifying forthcoming obstacles in the development of digital supply chain twins. The results of these investigations emphasise the significant impact that Industry 4.0 and 5.0 technologies can have on modernizing the agricultural and industrial sectors. By reconciling diverse perspectives and harmonizing definitions, they enhance a more unified and knowledgeable strategy for utilising these advancements to enhance efficiency, sustainability, and innovation in these vital sectors.

5. Discussion

The field of cloud computing has undergone significant transformations, evolving from its modest beginnings to becoming a crucial foundation of modern IT infrastructure. Virtualization and containerization have completely transformed the management and deployment of computing resources, offering unmatched scalability and efficiency advantages.When examining the timeframe between 2025 and 2030, several noticeable trends and challenges emerge.Many organizations are now embracing hybrid and multi-cloud strategies to tailor features and services to their unique requirements, all while mitigating the risks that come with relying solely on one vendor. Edge computing has the potential to address latency issues and promote a more competitive and equitable Internet of Things (IoT) ecosystem. At the same time, the integration of artificial intelligence and machine learning into cloud frameworks is poised to uncover new realms of creativity and improvement. However, even with these advancements, significant challenges remain. Ensuring strong security measures is crucial for safeguarding sensitive data and ensuring user privacy in the ever-evolving landscape of cyber threats. The ongoing price competition among cloud providers may lead to a constant decrease in service costs. This can be beneficial for consumers, but it may also affect the profitability of the providers. In addition, it is anticipated that cloud computing will be impacted by more stringent regulations in the future. These regulations will focus on protecting user rights and ensuring that providers are held responsible for data privacy and security.Given the current state of cloud computing, it is evident that it plays a vital role in driving digital innovation and empowering organizations. By embracing and leveraging cutting-edge technologies, addressing security considerations, and adapting to evolving regulatory landscapes, businesses can effectively harness the power of the cloud to seize new opportunities and stay ahead in a dynamic marketplace.

6. Implications

Everybody from academics to sustainable investors to professionals to lawmakers and politicians all stand to benefit from this study. Automated systems can aid financial institutions in identifying suspicious activity and preventing fraud. This safeguards customers' interests and forestalls monetary setbacks. Additionally, AI can sift through historical data in search of trends in risk and the market, enabling institutions to proactively lessen the impact of potential dangers. It also increases the profitability of banks while decreasing operational costs. Banking risk management using AI can enhance operational efficiency, customer experience, regulatory compliance, fraud detection, and risk assessment. Banks and customers both gain from this.Similar to other studies, this one has its limitations. If you only use SCOPUS data, you might be introducing bias into the process. It is possible that important publications using specialised vocabulary or novel terms went unnoticed, despite our best efforts.

7. Conclusion

The term "cloud computing" has been the subject of extensive research over the past two decades, both in terms of its definition and its development.The present study examines a total of 1,234 papers culled from 430 various sources obtained from the Scopus database, years 2022–2024. With 4,244 writers, with an average of 4.35 contributors per article. And worldwide cooperation was involved in 38.65 per cent. The authors have performed a bibliographic coupling technique based on documents by selecting a minimum of 30 citations per article.All three clusters show how different industries have made big strides in sustainability and technology. In Cluster 1, we look at ways to improve cybersecurity and the Internet of Things by combining edge computing with artificial intelligence and federated learning. Sustainable practices in Industry 4.0 are the subject of Cluster 2, which emphasizes HR strategies, regulatory frameworks, and industrial robots. In Cluster 3, we see how digital twins and zero-defect manufacturing are two examples of how Industry 4.0 and 5.0 are revolutionizing the agricultural and industrial sectors. Taken as a whole, these groups highlight how crucial current technology is for promoting efficiency, and sustainability.

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Conflicts of interest

The authors declare no conflicts of interest.

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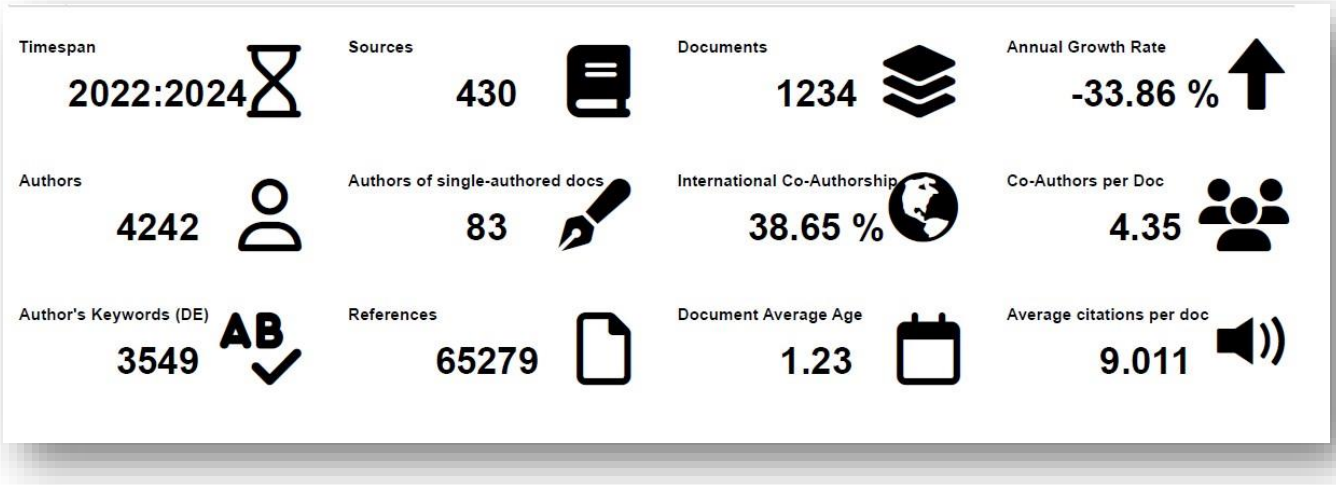

Fig 1: Main Information,

Source: R-Studio Output

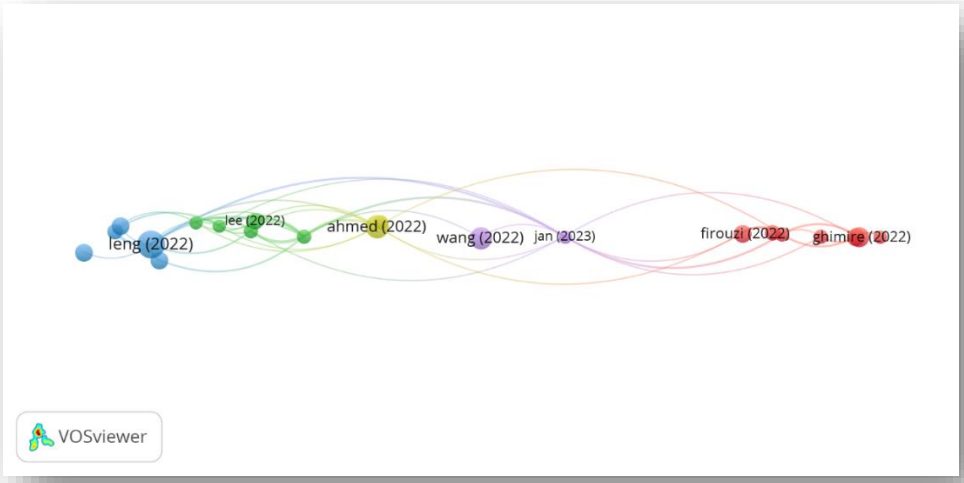

Fig 2 Thematic cluster analysis

Source: VOS-Viewer output