West Science Information System and Technology
Vol. 4, No. 02, August 2026, pp. 208~219

Bibliometric Analysis of Hybrid Cloud Computing

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Article Info

Article history:

Received Aug, 2026
Revised Aug, 2026
Accepted Aug, 2026

Keywords:

Hybrid Cloud Computing
Cloud Computing
Bibliometric Analysis
Edge Computing
VOSviewer

ABSTRACT

Hybrid cloud computing has emerged as a critical technological paradigm that enables organizations to combine the flexibility of public cloud services with the control and security of private cloud infrastructures. This study aims to examine the intellectual development, research trends, collaboration patterns, and emerging themes in hybrid cloud computing literature using a bibliometric analysis approach. Data were collected from the Scopus database and analyzed using VOSviewer to identify publication trends, influential literature, author and country collaboration networks, and keyword co-occurrence patterns. The findings reveal that hybrid cloud computing research has expanded significantly, with major contributions focusing on computation offloading, cloud-edge integration, Internet of Things (IoT), resource management, task scheduling, and optimization algorithms. Citation analysis highlights those influential studies primarily address improving computational efficiency, reducing latency, and optimizing resource utilization in distributed cloud environments. The collaboration analysis demonstrates that countries such as China, India, and the United States play central roles in advancing hybrid cloud research, although global collaboration remains concentrated within specific research networks. Furthermore, keyword analysis indicates a transition from traditional cloud infrastructure studies toward advanced research areas involving artificial intelligence, edge computing, cybersecurity, energy efficiency, and green computing. This study provides valuable insights into the evolution of hybrid cloud computing research and identifies future opportunities for developing intelligent, secure, and sustainable cloud ecosystems.

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1. INTRODUCTION

Cloud computing is currently among the most impactful technological paradigms for modern information systems, as it has changed the way computing resources, data storage, and digital services can be managed. Using cloud computing, organizations can become less dependent on infrastructural solutions and increase their flexibility and innovation potential [1]. The rapid emergence of cloud technologies has been fostered by growing demands on digital transformation, big data, artificial intelligence, and information systems that require flexible computational solutions [2], [3]. Moving

towards cloud platforms from traditional infrastructures, organizations have made cloud computing not only an alternative technological solution but also a strategic potential that facilitates their competitiveness and business agility [4]. Nevertheless, although cloud computing has numerous advantages, migration to cloud environments can be complicated due to issues related to security, privacy, and other factors.

Hybrid cloud computing is a technique which is being increasingly considered as an approach to counter the challenges associated with traditional infrastructure and pure cloud. In hybrid cloud computing, a combination of private cloud infrastructure and public cloud services is used where the distribution of workloads is based on certain criteria of performance, security, cost, and compliance [5], [6]. It offers a more flexible option since it makes it possible for organizations to keep their sensitive information and critical applications in private settings while still benefiting from the economies of scale provided by public cloud [7]. Hybrid cloud has been gaining increasing interest of firms because of its ability to combine innovation and risk management together. Firms are able to use the capabilities of cloud computing incrementally, improve resource allocation, keep more control over digital assets, while still being able to use cloud computing services provided externally [8], [9]. Hence, hybrid cloud computing is considered to be a very important architectural approach for digital transformation.

The increasing popularity of hybrid cloud computing technology has been impacted by new technologies such as edge computing, Internet of Things, artificial intelligence, and distributed data processing. Modern digital ecosystems require computing models that can support the processing of large amounts of data generated by users along with its analysis and dynamic load balancing. Hybrid cloud computing provides an efficient way for resolving the mentioned problem through the integration of centralized cloud computing and localized computing resources. Besides that, hybrid cloud computing contributes to building organizational resilience through workload mobility, disaster recovery solutions, and business continuity planning [10]. Moreover, recent researches have found out that organizations increasingly see hybrid cloud computing not as a technical approach to build their infrastructure but as an innovation enabler and means for competitive advantages [11], [12]. The mentioned change proves that hybrid cloud computing has become a multidimensional field of study.

Despite the numerous advantages that come with the adoption of hybrid cloud computing technology, there are quite many challenges associated with it that need to be constantly researched. The problems connected with interoperability, multi-cloud management, cybersecurity risks, cloud governance tools, and cloud service integration still stand out as the major obstacles for successful use of hybrid cloud systems [13]. Furthermore, the growing complexity of hybrid clouds poses certain challenges related to ensuring consistency of security policy, protection of information resources, and orchestration of IT resources. Besides that, the organizations face such challenges as the vendor lock-in, compliance issues, and cloud governance frameworks development. This has caused scientists to research different aspects of hybrid cloud computing including architectures, security measures, performance improvement, and adoption factors among others. The scientific literature on hybrid cloud computing has increased significantly making it necessary to systematically analyze.

Taking into account the fast-growing rate of interdisciplinary studies of hybrid cloud computing, the use of bibliometric analysis would be a proper methodology to study the evolution, structure, and emerging trends in the field under consideration. With the help of bibliometric analysis, it is possible to conduct a quantitative examination of scientific works using indicators like publication growth, citations, influential authors, institutions, keyword clustering, and research clusters [14]. Contrary to traditional literature review methods which concentrate

mainly on the qualitative approach to the study of literature, bibliometrics offers a broad overview of research development and intellectual structures of a specific sphere of study. The previous research proves the effectiveness of bibliometric analysis in exploring the area of technology research, defining the gaps in knowledge, and forecasting the further directions of research.

Despite the rising significance of hybrid cloud computing, research to date has been scattered across various technological and managerial angles. Separate works have been done on the architecture, security, adoption model, performance optimization, and organizational aspects of hybrid clouds. Consequently, the holistic intellectual structure and development history of this literature has been largely understudied. Besides, the frequent introduction of novel ideas such as cloud-native systems, edge-cloud, AI cloud management, and multi-cloud strategy has further made the research domain dynamic. A systematic analysis of trends in publications, influential publications, major themes, and novel directions of research is necessary to help stakeholders understand the present state of knowledge and set research priorities for the future. Hence, there is a need for bibliometric analysis in order to map out the development history of the literature.

This research is devoted to performing a bibliometric analysis on the topic of hybrid cloud computing in order to reveal the dynamics of publications, prominent scientific contributions, topical research problems, and new tendencies in this sphere. In particular, this study considers the development of literature on hybrid cloud computing based on bibliometric indicators such as performance, citation, keyword co-occurrence, collaboration, and thematic evolution. Offering an overview of the current state of research on the topic, this study strives to make its contribution to the analysis of knowledge structures in the area of hybrid cloud computing and identify possible areas of further research. It is supposed that the results obtained will be helpful for researchers, technologists, and organizations to understand the strategic importance of hybrid cloud computing for modern digital transformation.

2. METHODS

The current research applies a bibliometric analysis method to systematically investigate the evolution, structure, and research trends within the field of hybrid cloud computing. A bibliometric analysis is defined as a quantitative research approach which assesses scientific publications using statistical and network analysis methods in order to reveal patterns of knowledge development, key contributions, and directions for future research [14]. A bibliometric analysis was chosen since the field of hybrid cloud computing belongs to an interdisciplinary research area, which is rapidly developing and includes computer science, information systems, cybersecurity, cloud infrastructure, and digital transformation. Therefore, the aim of the research is to conduct a systematic investigation of the intellectual structure of the hybrid cloud computing field instead of researching particular findings.

The data source of this research work was gathered from the Scopus database due to its large coverage of peer-reviewed scientific publications and appropriate use for bibliometric research. For the purposes of the literature review, the combination of keywords associated with the topic of hybrid cloud computing was used, namely the inclusion of the phrase “hybrid cloud computing” in the title, abstract, and keywords of an article. It should be noted that during the literature search, it is taken into consideration relevant articles during the period of availability of the database regardless of particular publication years in order to gather publications from historical perspectives as well as new advances in the field of research. During the data selection, only relevant scientific publications concerning hybrid cloud computing are chosen considering publication relevancy, document type, and publication quality. The bibliographic information consisted of the

name of a publication, author names, affiliation, countries, abstracts, keywords, citation data, and publication sources.

The bibliographic records were subjected to analysis by way of bibliometrics using visualisation and mapping through the aid of VOSviewer number of analysis were carried out including publication trend analysis, citation analysis, co-authorship analysis, keyword co-occurrence analysis, and thematic mapping. Analysis of publications and citations were done in order to discover important studies, authors, and sources that contribute to the growth of research on hybrid cloud computing. Co-authorship analysis was used to investigate patterns of collaboration among researchers and institutions, while keyword co-occurrence analysis was used to discover the key research themes and connections between major themes in the field of study. In addition, analysis of thematic evolution was done in order to understand the changes in research themes over time and future possible directions for studies in hybrid cloud computing.

3. RESULTS AND DISCUSSION

3.1 Co-Authorship Analysis

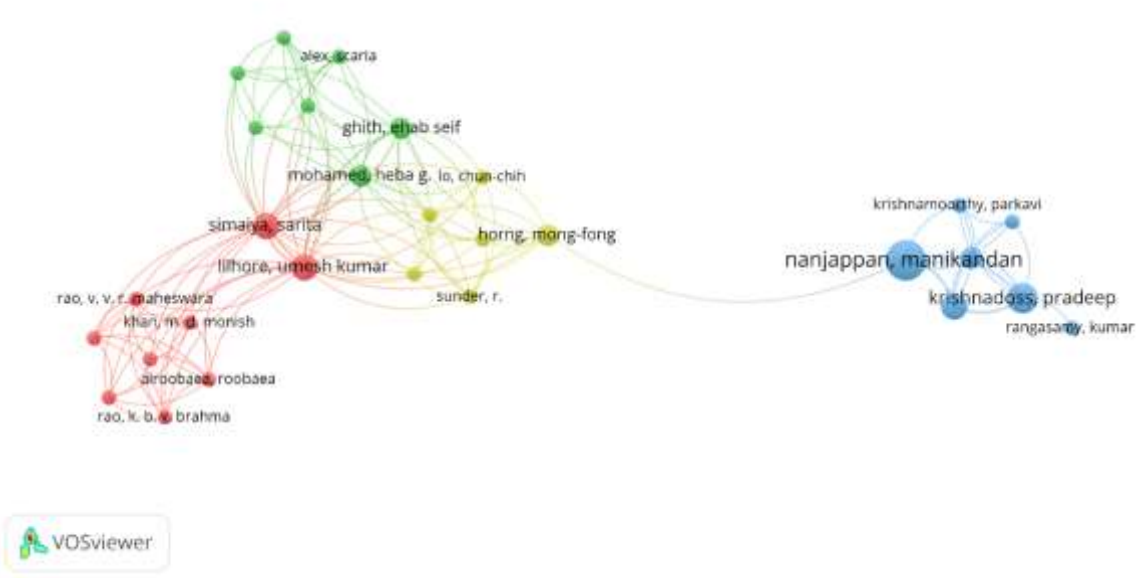

Figure 1. Author-Level Visualization
Source: Data Analysis

Figure 1 depicts the presence of several research collaboration clusters within the domain of hybrid cloud computing. The network has been segregated into four main clusters, with each of these being denoted by color coding, which shows a cluster of researchers who collaborate frequently among themselves. The red colored cluster is a relatively dense cluster of researchers such as Simaiya, Sarita; Tithore, Umesh Kumar; Khan, M. D. Monish; and Rao, V. V. R. Maheshwara, representing a research group that is highly focused towards certain aspects of cloud computing. The green and yellow colored clusters are interlinked collaboration clusters, where the authors include Alex Scaria, G. Hith, Ehab Seif, Mohamed Heba, Lo Chun-Chih, Horng Mong-Fong, and Sunder R.

Blue cluster, which is formed by authors like Nanjappan Manikandan, Krishnamoorthy Parkavi, Krishnadoss Pradeep, and Rangasamy Kumar, acts as a separate collaboration cluster with minimal

linkages with other clusters. The large size of the node for certain authors suggests their high productivity or prominence in the collaboration network. Also, thick lines signify the level of collaboration among researchers.

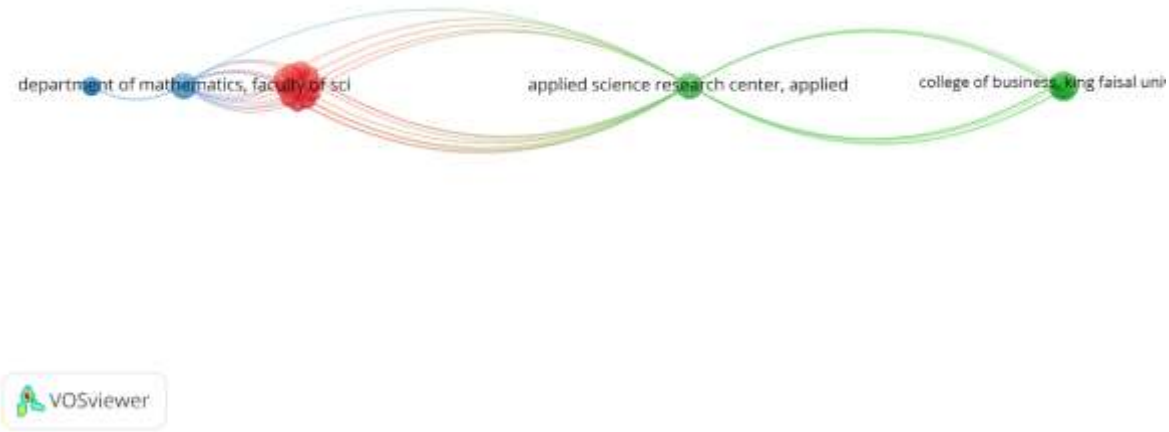

Figure 2. Institution-Level Visualization
Source: Data Analysis

The second figure below indicates a somewhat constrained yet distinctively interconnected network amongst entities conducting research in the domain of hybrid cloud computing. This is an organizational network composed of various institutional nodes linked through certain central organizational nodes; the Applied Science Research Center appears to be one of the significant intermediary nodes which link various research organizations together. It is evident from the network graph that the Department of Mathematics, Faculty of Science is highly connected with other organizations, emphasizing the significant role it plays in collaborating in research activities.

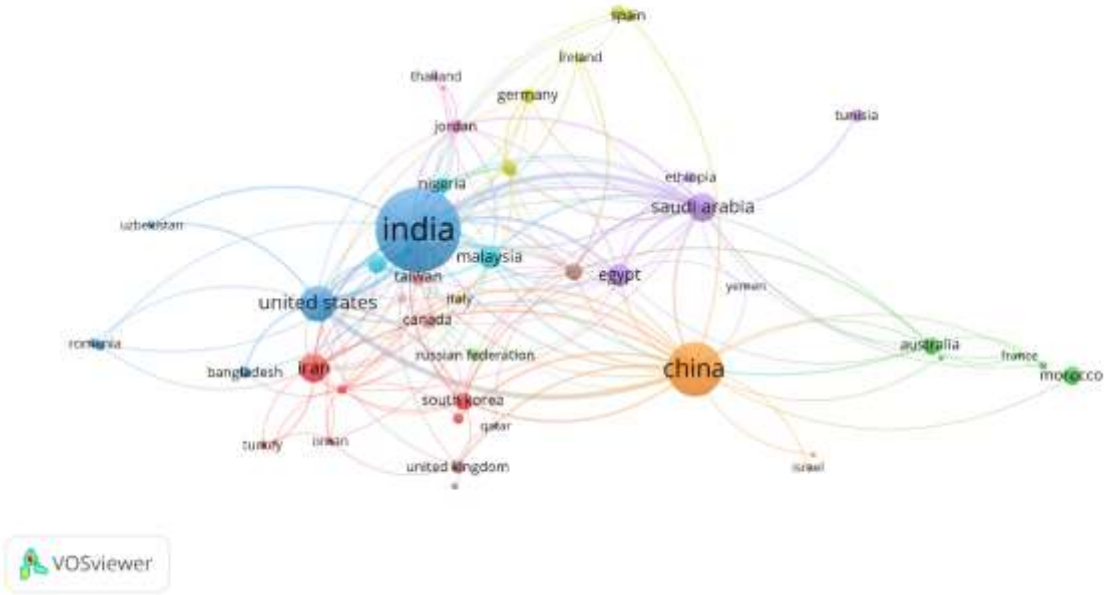

Figure 3. Country-Level Visualization
Source: Data Analysis

Figure 3 provides an overview of the global research landscape in hybrid cloud computing, and there are many collaboration clusters that can be observed from the figure. China and India have been identified as the leading countries because of the biggest nodes, which indicate their high research activity and contributions to the field. It is apparent that China has extensive collaborations with countries from other parts of the world, including Australia, France, Saudi Arabia, and Israel. Likewise, India has a good connection with countries such as the US, Saudi Arabia, Malaysia, Taiwan, and European countries. The other countries like the US, Saudi Arabia, Iran, and Germany have been serving as connecting nodes as well.

The network structure shows that hybrid cloud computing research has developed through multiple interconnected international collaboration groups rather than being dominated by a single country. The presence of links among Asian, European, Middle Eastern, and Western countries indicates increasing global interest in hybrid cloud technologies. However, some countries, such as Morocco, Tunisia, Uzbekistan, and Romania, appear on the network periphery with fewer connections, suggesting relatively limited participation in international research collaboration

3.2 Citation Analysis

Table 1. The Most Impactful Literatures

Citations	Authors and year	Title
411	[15]	Computation Offloading in LEO Satellite Networks with Hybrid Cloud and Edge Computing
376	[16]	The impact of the hybrid platform of internet of things and cloud computing on healthcare systems: opportunities, challenges, and open problems
363	[17]	Hybrid Method for Minimizing Service Delay in Edge Cloud Computing Through VM Migration and Transmission Power Control

Citations	Authors and year	Title
312	[18]	A hybrid model of Internet of Things and cloud computing to manage big data in health services applications
311	[19]	A parallel bi-objective hybrid metaheuristic for energy-aware scheduling for cloud computing systems
274	[20]	A novel hybrid antlion optimization algorithm for multi-objective task scheduling problems in cloud computing environments
239	[21]	Scheduling Internet of Things requests to minimize latency in hybrid Fog–Cloud computing
235	[22]	Multi-Objective Task Scheduling Optimization for Load Balancing in Cloud Computing Environment Using Hybrid Artificial Bee Colony Algorithm with Reinforcement Learning
228	[23]	Task scheduling in cloud computing based on hybrid moth search algorithm and differential evolution
221	[24]	Workflow Scheduling Using Hybrid GA-PSO Algorithm in Cloud Computing

Source: Scopus, 2026

Table 1 below shows the most influential pieces of literature in hybrid cloud computing research with their citations numbers, where the most influential papers which shaped the area of research in terms of citations are presented. The paper with the highest number of citations 411 by [15] is devoted to computation offloading in LEO satellite network through hybrid cloud and edge computing, which underlines the growing significance of combination of cloud and edge computing infrastructure in order to increase computational efficiency. The second most influential piece of literature with the number of citations 376 by [16] investigates the integration of IoT and cloud computing in healthcare systems, showing the significance of hybrid cloud solutions for data-intensive and critical systems. Other highly cited papers stress important research topics such as edge-cloud optimization, management of big data in healthcare, energy-aware cloud scheduling, task scheduling optimization, and hybrid metaheuristic algorithms.

3.3 Keyword Co-Occurrence Analysis

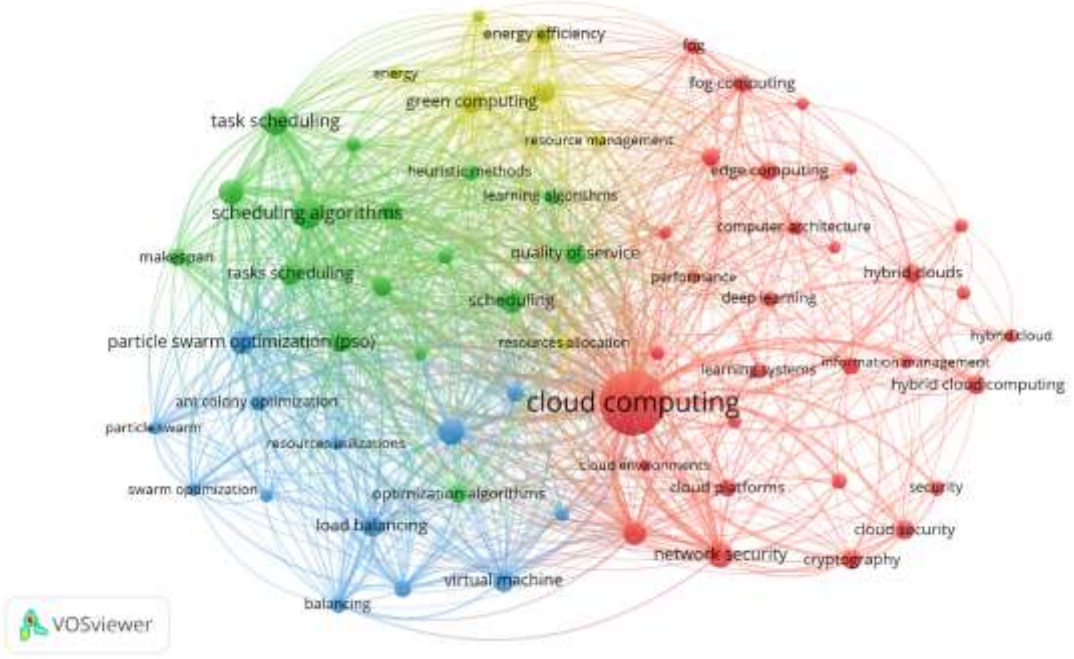

Figure 4. Network Visualization
Source: Data Analysis

Figure 4 below shows the main research areas and the intellectual structure of studies on hybrid cloud computing. In this figure, the network is built upon the dominant keyword, "cloud computing" denoted as the biggest node, which implies that "cloud computing" is the main keyword linking different research areas. The highly connected nature of the nodes linked to the dominant keyword reveals the connection of hybrid cloud computing research to numerous technological areas such as cloud computing, optimization, security, edge computing, and intelligent computing among others.

The red-colored cluster indicates the major research topic, which deals with the hybrid cloud architecture, cloud security, edge computing, and intelligent cloud management. Some of the keywords from the above-mentioned cluster include hybrid cloud, hybrid cloud computing, edge computing, fog computing, deep learning, network security, and cryptography. It is evident that current researches have highlighted the incorporation of hybrid clouds along with some emerging concepts. These concerns highlight the security issues in relation to data management, distributed computing models, and intelligent systems to enhance cloud computing efficiency. The association of hybrid cloud and security issues clearly shows that data security is one of the major issues in hybrid cloud environments.

The green color group represents papers which study the area of optimization, scheduling and energy efficiency of cloud resources. The use of keywords like scheduling algorithm, task scheduling, resource management, green computing, energy efficiency and heuristic approach suggests that researchers are concerned about improving the performance of cloud systems using efficient allocation and management of computing resources. It shows the significance of optimizing the distribution of load, energy savings, and Quality of Service (QoS) in large cloud systems. Machine learning and heuristic approaches being used in this group suggest a new trend in cloud systems optimization.

Clustered in blue color are those articles which have addressed problems in terms of optimization algorithms and balancing of computational resources. The keywords like particle swarm optimization

(PSO), ant colony optimization, swarm optimization, load balancing, virtual machine, and optimization algorithms indicate the use of meta-heuristic techniques in resolving problems associated with cloud computing environment. Scholars working in this cluster try to explore how these intelligent optimization techniques can be used for improving virtual machine placement and workload balancing in hybrid clouds.

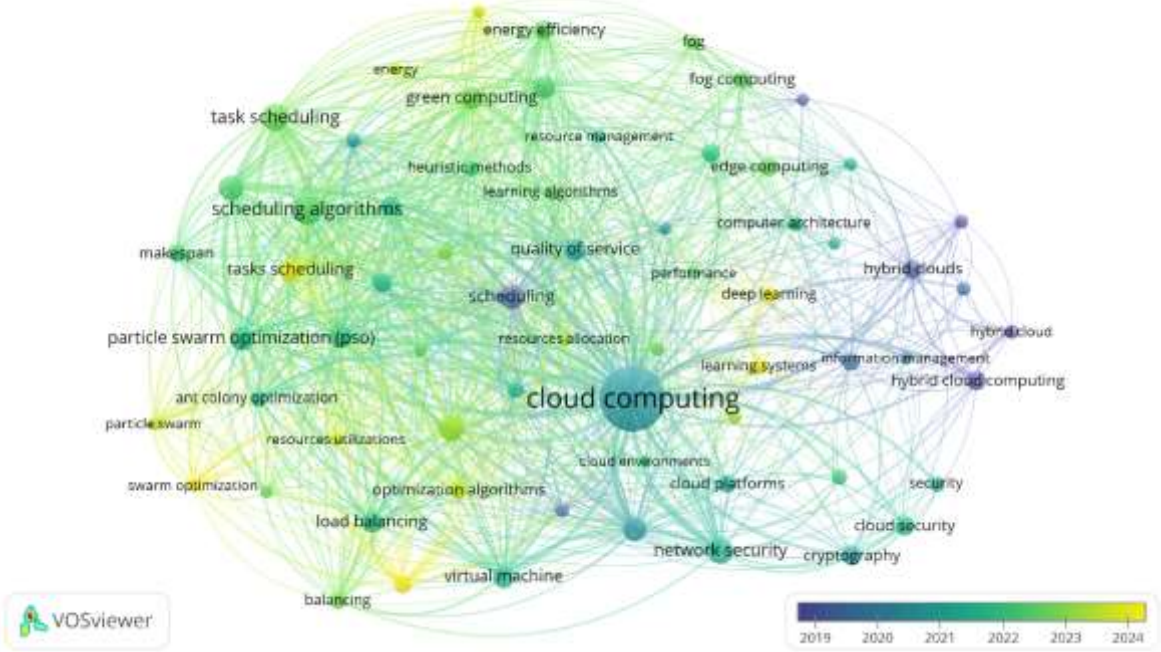

Figure 5. Overlay Visualization
Source: Data Analysis

Figure 5 demonstrates the timeline of research themes in hybrid cloud computing in accordance with the patterns of keyword usage. The color scale reflects the average period of publication, whereby blue corresponds to older studies (approximately 2019–2020), while green and yellow correspond to relatively new ones (2022–2024). The central keyword "cloud computing" has been the main and constantly evolving research theme, thus highlighting its significant importance in the interrelation between different technological themes. The color distribution around the network suggests that the research in hybrid cloud computing has gradually moved beyond the basic research of cloud infrastructure into such domains as optimization, intelligence, and sustainability.

Keywords from previous research studies are primarily related to basic cloud computing management and optimization of infrastructure, and they include virtual machine, load balancing, network security, cryptography, and cloud computing. These subjects demonstrate the initial focus of cloud computing research, especially on enhancing reliability, resource allocation, and security in the cloud computing environment. With the passage of time, the focus of cloud computing research has evolved toward adaptation and intelligence, which is evident from the occurrence of new keywords such as hybrid cloud computing, edge computing, fog computing, deep learning, and learning systems.

The latest trends in research can be found through terms with yellow-green colors. This includes energy efficiency, green computing, task scheduling, optimization algorithms, and heuristics. Such new trends imply that recent studies on hybrid cloud computing tend to concentrate more on sustainable and intelligent ways to manage resources. The increasing interest in such areas as energy-efficient scheduling,

optimization using machine learning, and algorithms demonstrates that there is a trend towards autonomous cloud computing.

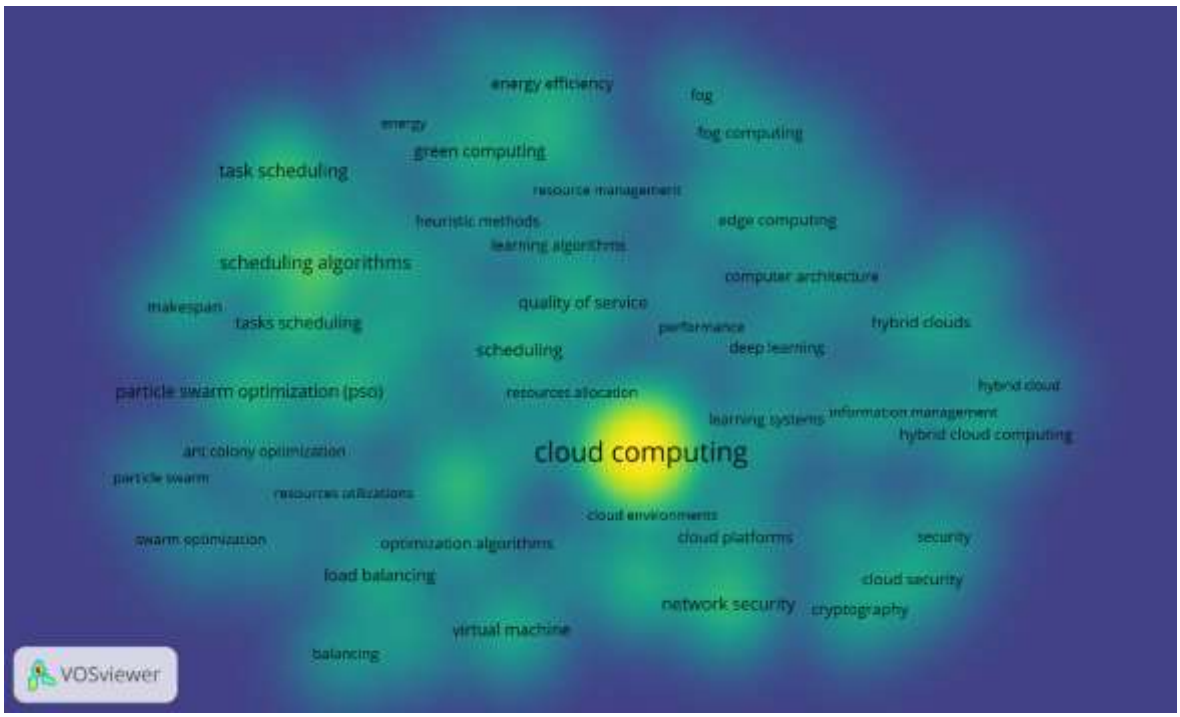

Figure 6. Density Visualization
Source: Data Analysis

Figure 6 concentration and density of research topics in hybrid cloud computing researches. The highlighted zone with the highest density is located at the center of the keyword "cloud computing", which means that it forms the core of research studies and the most common topic discussed in literature. Dense areas surrounding this central keyword suggest that there are close ties between the central keyword and related topics like cloud environments, cloud platform, resource management, scheduling, and optimization algorithms. This means that many studies in hybrid cloud computing concentrate on improving cloud performance and computational resource management.

There is a number of other areas of high density where different research areas are found such as task scheduling, scheduling algorithm, energy efficiency, green computing, edge computing, and security. This fact proves that there is a trend in the development of research, where the focus is shifted to solving issues regarding effective use of resources, sustainable cloud computing, and interaction between cloud, edge, and fog computing platforms. Moreover, there are also new research areas identified such as deep learning, learning systems, hybrid cloud computing, network security, and cryptography.

4. CONCLUSION

This bibliometric analysis provides a comprehensive overview of the evolution, intellectual structure, and emerging research directions in hybrid cloud computing. The findings demonstrate that hybrid cloud computing has developed into a multidisciplinary research field involving cloud infrastructure, edge computing, artificial intelligence, optimization algorithms, cybersecurity, and sustainable computing. The analysis of impactful literature shows that major research contributions have focused on computation offloading, IoT-cloud integration, resource scheduling, and optimization techniques to

improve cloud performance and efficiency. The collaboration analysis indicates that research activities are globally distributed, with countries such as China, India, and the United States playing significant roles in advancing the field, although international collaboration remains concentrated among specific research groups and institutions. Furthermore, the keyword analysis reveals that the research focus has gradually shifted from traditional cloud management toward intelligent, adaptive, and sustainable hybrid cloud ecosystems. Current trends emphasize energy-efficient resource allocation, AI-driven optimization, edge-fog-cloud integration, and enhanced security mechanisms. The emergence of these themes indicates that future hybrid cloud computing research will likely concentrate on developing autonomous cloud architectures capable of optimizing performance, reducing operational costs, and ensuring secure data management.

REFERENCES

[1] H. Turabieh and N. Abu-el-rub, "Intrusion Detection Using Hybrid Long Short-Term Memory with Binary Particle Swarm Optimization for Cloud Computing Systems," *A Step Towards Society 5.0: Research, Innovations, and Developments in Cloud-Based Computing Technologies*. CRC Press, pp. 147–159, 2021. doi: 10.1201/9781003138037-8.

[2] H. Abroshan, "A Hybrid Encryption Solution to Improve Cloud Computing Security using Symmetric and Asymmetric Cryptography Algorithms," *Int. J. Adv. Comput. Sci. Appl.*, vol. 12, no. 6, pp. 31–37, 2021, doi: 10.14569/IJACSA.2021.0120604.

[3] S. A. A. M. Zarif *et al.*, "GLOPS: A Hybrid Approach for Enhanced Scheduling in Cloud Computing Environments via Machine Learning-Based Process Prediction," *IEEE Access*, vol. 13, pp. 134385–134402, 2025, doi: 10.1109/ACCESS.2025.3592211.

[4] K. P. Jasuja and K. Kaur, "Hybrid soft computing approach for energy efficiency in cloud computing," in *Proceedings of the International Conference on Communication and Electronics Systems, ICCES 2016*, Department of Computer Science, Bhai Maha Singh College of Engineering, Muktsar, India: Institute of Electrical and Electronics Engineers Inc., 2016. doi: 10.1109/CESYS.2016.7889945.

[5] A. Roy, S. Midya, K. Majumder, and S. Phadikar, "Distributed resource management in dew based edge to cloud computing ecosystem: A hybrid adaptive evolutionary approach," *Trans. Emerg. Telecommun. Technol.*, vol. 31, no. 8, 2020, doi: 10.1002/ett.4018.

[6] J. Zheng and Y. Wang, "A hybrid multi-objective bat algorithm for solving cloud computing resource scheduling problems," *Sustain.*, vol. 13, no. 14, 2021, doi: 10.3390/su13147933.

[7] T. Sharma, "Proposed hybrid RSA algorithm for cloud computing," in *Proceedings of the 2nd International Conference on Inventive Systems and Control, ICISC 2018*, CSE Department Amritsar College of Engineering and Technology, Amritsar, India: Institute of Electrical and Electronics Engineers Inc., 2018, pp. 60–64. doi: 10.1109/ICISC.2018.8398902.

[8] S. Sakri and A. S. Alluhaidan, "RHEM: A Robust Hybrid Ensemble Model for Students' Performance Assessment on Cloud Computing Course," *Int. J. Adv. Comput. Sci. Appl.*, vol. 11, no. 11, pp. 388–396, 2020, doi: 10.14569/IJACSA.2020.0111150.

[9] H. Zhang, G. Jiang, K. Yoshihira, and H. Chen, "Proactive workload management in hybrid cloud computing," *IEEE Trans. Netw. Serv. Manag.*, vol. 11, no. 1, pp. 90–100, 2014, doi: 10.1109/TNSM.2013.122313.130448.

[10] F. A. Osuolale, "Reactive Hybrid Model for Fault Mitigation in Real-Time Cloud Computing," *Int. J. Cloud Appl. Comput.*, vol. 12, no. 1, 2022, doi: 10.4018/IJCAC.295240.

[11] S.-J. Yang and Y.-H. Huang, "Design Issues of a Hybrid Wrapping Attack Protecting Scheme in Cloud Computing Environment," *Lecture Notes on Data Engineering and Communications Technologies*, vol. 41. Springer Science and Business Media Deutschland GmbH, Department of Computer Science and Information Management, Soochow University, Taipei, Taiwan, pp. 113–127, 2020. doi: 10.1007/978-3-030-34986-8_8.

[12] Y. Sharma and A. S. Baghel, "ColdStartNet: A Hybrid Stacked Model for Proactive Cold Start Latency Prediction in Cloud & Edge Computing," in *Lecture Notes in Networks and Systems*, N. G.-N., S. A., and S. P., Eds., University School of Information and Communication Technology, Gautam Buddha University, Uttar Pradesh, Greater Noida, India: Springer Science and Business Media Deutschland GmbH, 2026, pp. 344–354. doi: 10.1007/978-3-032-14197-2_30.

[13] N. S. Hamed Alzadjali, N. Jabeen T, H. Vijaykumar, and K. Maheswari, "Energy Efficiency in Cloud Computing using Hybrid Algorithm," in *5th International Conference on Inventive Computation Technologies, ICICT 2022 - Proceedings*, University of Technology and Applied Sciences, Al Mussanah, Oman: Institute of Electrical and Electronics Engineers Inc., 2022, pp. 920–927. doi: 10.1109/ICICT54344.2022.9850926.

[14] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, pp. 285–296, 2021.

[15] Q. Tang, Z. Fei, B. Li, and Z. Han, "Computation Offloading in LEO Satellite Networks with Hybrid Cloud and Edge Computing," *IEEE Internet Things J.*, vol. 8, no. 11, pp. 9164–9176, 2021, doi: 10.1109/JIOT.2021.3056569.

[16] A. Darwish, A. E. Hassanien, M. Elhoseny, A. K. Sangaiah, and K. Muhammad, "The impact of the hybrid platform of internet of things and cloud computing on healthcare systems: opportunities, challenges, and open problems," *J. Ambient Intell. Humaniz. Comput.*, vol. 10, no. 10, pp. 4151–4166, 2019, doi: 10.1007/s12652-017-0659-1.

[17] T. G. Rodrigues, K. Suto, H. Nishiyama, and N. Kato, "Hybrid Method for Minimizing Service Delay in Edge Cloud Computing Through VM Migration and Transmission Power Control," *IEEE Trans. Comput.*, vol. 66, no. 5, pp. 810–819, 2017, doi: 10.1109/TC.2016.2620469.

[18] M. Elhoseny, A. Abdelaziz, A. S. Salama, A. M. Riad, K. Muhammad, and A. K. Sangaiah, "A hybrid model of Internet of Things and cloud computing to manage big data in health services applications," *Futur. Gener. Comput. Syst.*, vol. 86, pp. 1383–1394, 2018, doi: 10.1016/j.future.2018.03.005.

[19] M. Mezmaz *et al.*, "A parallel bi-objective hybrid metaheuristic for energy-aware scheduling for cloud computing systems," *J. Parallel Distrib. Comput.*, vol. 71, no. 11, pp. 1497–1508, 2011, doi: 10.1016/j.jpdc.2011.04.007.

[20] L. Abualigah and A. Diabat, "A novel hybrid antlion optimization algorithm for multi-objective task scheduling problems in cloud computing environments," *Cluster Comput.*, vol. 24, no. 1, pp. 205–223, 2021, doi: 10.1007/s10586-020-03075-5.

[21] R. O. Aburukba, M. AliKarrar, T. Landolsi, and K. El-Fakih, "Scheduling Internet of Things requests to minimize latency in hybrid Fog–Cloud computing," *Futur. Gener. Comput. Syst.*, vol. 111, pp. 539–551, 2020, doi: 10.1016/j.future.2019.09.039.

[22] B. Kruekaew and W. Kimpan, "Multi-Objective Task Scheduling Optimization for Load Balancing in Cloud Computing Environment Using Hybrid Artificial Bee Colony Algorithm with Reinforcement Learning," *IEEE Access*, vol. 10, pp. 17803–17818, 2022, doi: 10.1109/ACCESS.2022.3149955.

[23] M. A. Elaziz, S. Xiong, K. P. N. Jayasena, and L. Li, "Task scheduling in cloud computing based on hybrid moth search algorithm and differential evolution," *Knowledge-Based Syst.*, vol. 169, pp. 39–52, 2019, doi: 10.1016/j.knosys.2019.01.023.

[24] A. M. Manasrah and H. B. Ali, "Workflow Scheduling Using Hybrid GA-PSO Algorithm in Cloud Computing," *Wirel. Commun. Mob. Comput.*, vol. 2018, 2018, doi: 10.1155/2018/1934784.