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October 2020

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Waghmare, Prakash B., "INDIAN RESEARCH CONTRIBUTION IN CLOUD COMPUTING: A BIBLIOMETRIC ANALYSIS AND VISUALIZATION OF JOURNAL ARTICLES FROM SCOPUS DATABASE" (2020). *Library Philosophy and Practice (e-journal)*. 4354.

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# **INDIAN RESEARCH CONTRIBUTION IN CLOUD COMPUTING: A BIBLIOMETRIC ANALYSIS AND VISUALIZATION OF JOURNAL ARTICLES FROM SCOPUS DATABASE**

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## **ABSTRACT**

The present bibliometric study aims to analyze the Indian research contribution in cloud computing from 2011 to 2020. The data was collected from Scopus database using "cloud Computing" keyword and limited to articles final publications. The study analysis many bibliometric parameters like; year-wise distribution of publications; most productive authors, titles, sources and citation counts. Co-occurrence of keywords from articles and authors keywords mapping through VOSviewer. The study found a total 1482 articles, highest 439 articles were published in 2019. The article entitled Honey bee behavior inspired load balancing of tasks in cloud computing environments published in 2013 received highest citation i.e 386. Chana, I., Kumar N, Iyengar are the prolific authors. Vellore Institute of Technology, Vellore is the top contributing Institute.

**KEYWORDS :** Bibliometric; Citations; Cloud Computing; Co Journals; Keywords Co-occurrence; Prolific Authors; Scopus Database; Top Institutions; VOS Viewer;

## **1. INTRODUCTION**

Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user. Cloud computing is a service through which one can access remote application server and consume computing services through the internet (Bharati & Singh, 2019). The term cloud was used to refer to platforms for distributed computing. ("Cloud Computing," 2020). The goal of cloud computing is to allow users to take benefit from all of these technologies, without the need for deep knowledge about or expertise with each one of them. The cloud aims to cut costs and helps the users focus on their core business instead of being impeded by IT obstacles. The main enabling technology for cloud computing is virtualization. Virtualization software separates a physical computing device into one or more "virtual" devices, each of which can be easily used and managed to perform computing tasks (Hamdaqa & Tahvildari, 2012).

In this emerging technological world, cloud computing is one of the efficient technological services for storing and retrieving data & resources through the internet, cloud network (Malleswaran et al., 2020) rather than direct service connection with some security features like third party stores the data which may attract exploitation but it also offers security tools with disadvantages of lack of safety standards, data management (Rengasamy & Chidambaram, 2020), data warehouse (Deb & Kirubanand, 2020), users are faced with various data security and personal privacy risks when using cloud services (Damera et al., 2020) and so on (Gobi & Parimalam, 2020) Cloud computing makes data available to the end user in a 24 x 7 x 365 access time, anywhere and anything (Senthil Kumari & Nadira Banu Kamal, 2020).

Storing and analyzing Big-Data in cloud computing is now gaining popularity. Together, these two technologies provide powerful information and benefits for the business but firstly the big-data analysis requires a great deal of computational resources. This is considered a barrier to big-data analysis. Data security becomes a question mark when we store big-data in the cloud (Jayaraj & Abdul Samath, 2020) thus for successfully executing cloud computing, inclusive knowledge and its management in a skillful manner is a mandate (Bahrami & Harish Babu, 2020).

This decade has been proved for the large number of research on cloud computing on the view of further improvement and development and the output has been getting published widely. Despite the rapidly growing research, publication and popularity of studies on cloud computing seems to be insufficiently mapped. Only few bibliometric studies were found on cloud computing. The author selected cloud computing for bibliometric study which analyses the document types, language, publication output, citations, authorship pattern, journals, prolific authors, productive countries and most frequently appeared top words/phrases from the title of the articles (Kolle et al., 2018).

## **2. REVIEW OF RELATED STUDIES**

In the present decade, publications are multiplying on cloud computing and bibliometric analysis is a need of the era but a very few bibliometric studies on cloud computing have been undertaken. The author has searched Emerald, Scopus, Web of Science and Google Scholar databases on 26.08.2020 and retrieved only few publications on cloud computing Bibliometric and Scientometrics studies. The studies like Scientometrics analysis of cloud computing (Jan et al., 2015), International cloud computing literature: A Scientometrics analysis for 2004-13 (Gupta et al., 2015) A bibliometric analysis of World research output on cloud computing (Chaurasia et al., 2016) and A Scientometrics analysis of cloud computing literature (Heilig & Voß, 2014) relatively have been done.

Scopus based bibliometric analyses of research publications on cloud computing with various parameters like publishing patterns, analysis of common key terms, key term bunching to identify domain of interest, citation patterns, publications medium, and aid in exploring research productivity in this specific domain has been done further analyzed the literature based on the quantitative features and characteristics of cloud security and the researcher stated that, it is important to state the existing status of research and a bibliometric analysis is a need of the hour (Garg et al., 2019).

Cloud computing plays a key role in the development of Modern Library and rejuvenate rapidly through cloud computing (Bharati & Singh, 2019). The Bibliometric study of the publication on cloud computing has been done from Web of Science Core collection database. Total 11776 articles were retrieved and analyzed.. R. Buyya is top author with 138 articles followed by J. Lee with 114. In 2018, there were 2667 papers published on computing cloud followed by 2247 in year 2017. Chine is on top followed by USA and India is on third position with 997 research papers. The Top Journal is Future Generation Computer Systems the International Journal of Escience Followed by IEEE Access and Journal of Supercomputing.

Yu et al., (2018) did a Bibliometric Analysis of Cloud Computing Technology Research using Excel, Bibexcel, VOSviewer and Cite Space software for data mining and quantitative analysis of the 2005-2018 year research papers on cloud computing from Web of Science.

Chinese Academy of Sciences is very active in the research of cloud computing, and its papers are far ahead of other institutions. The main focuses of the study are virtualization, mobile cloud computing, big data, security, etc. The main hot spots of research are mobile cloud computing, big data, fog computing, secure, storage, access control, sever consolidation, etc (Yu et al., 2018).

Cai, Y. (2015) published paper on Cloud Computing Research Analysis Using Bibliometric Method. In this paper, a bibliometric-based approach is presented and implemented to quantitatively review the progress in global cloud computing research with the related literature during 2007-2013 from the databases of Science Citation Index Expanded (SCI-E), Conference Proceedings Citation Index-Science (CPCI-S), and IEEE Xplore. Study shown top 5 active research points of cloud computing concentrate on virtualization, security, mobile cloud, distributed computing, and scheduling. Meanwhile, the results demonstrate the top 3 high-cited research institutes of the University of Melbourne, University of California. Berkeley and University of Vienna in cloud computing research (Cai et al., 2015).

### **3. OBJECTIVES AND SCOPE OF THE STUDY**

The objectives remain to study all the parameters of bibliometric of the articles published on cloud computing and the scope is limited to Indian publication in SCOPUS database from 2011 to 2020 further the main objectives of the study are as follows:

- 3.1 To examine the status of published articles on cloud computing;
- 3.2 To identify the highly-cited articles on cloud computing;
- 3.3 To identify the top prolific authors in the field of cloud computing;
- 3.4. To identify the top institutes publishing articles on cloud computing;
- 3.5 To visualize the keywords co-occurrence map of cloud computing articles;
- 3.6. To visualize Co-occurrence map of author keywords/terms;

### **4. MATERIALS AND METHODS ADOPTED**

The data on research publications related to "Cloud Computing" was collected from the Scopus database on September 17, 2020 by using the following search strategy: TITLE ( "cloud computing" ) AND ( LIMIT-TO ( PUBSTAGE , "final" ) ) AND ( LIMIT-TO ( AFFILCOUNTRY , "India" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ). A total of 1482 articles were identified through the search. Information such as title, authors, journal, year, citations, author address, author keywords, and index keywords were downloaded into a Microsoft Excel spreadsheet and was employed for analysis, with manual coding wherever necessary. VOSviewer software is used for visualization presentation. Method for mapping the state of the art and identifying gaps and trends of research has been extracted from (José de Oliveira et al., 2019).

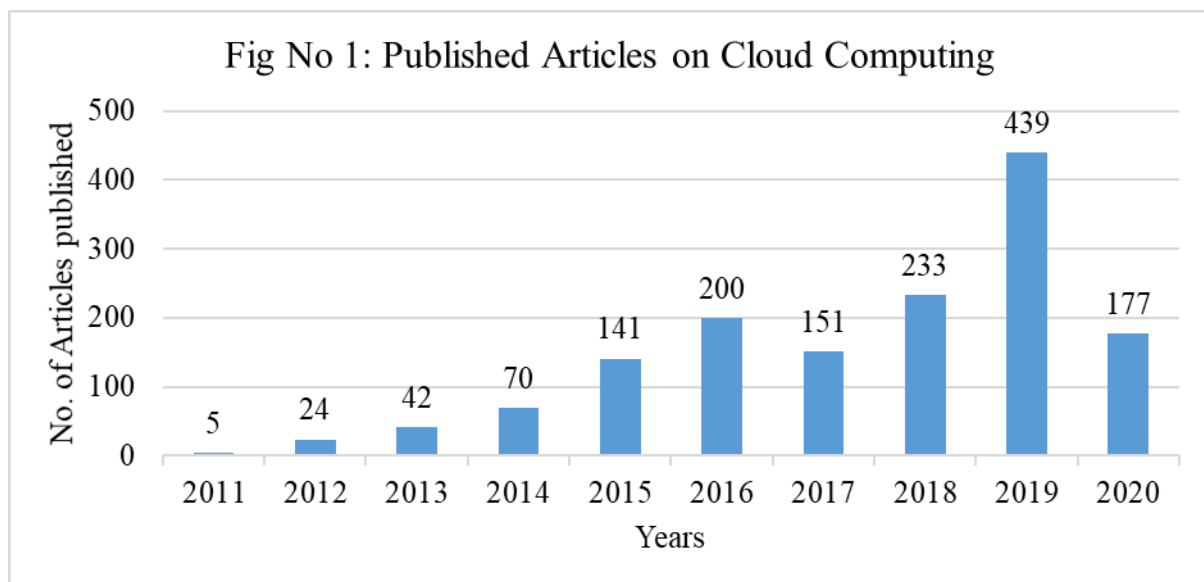
### **5. RESULTS AND ANALYSIS**

#### *5.1 Status of published articles on cloud computing*

1482 articles have been retrieved from the search strategy mentioned above presented in table no 1. There is an increasing tendency in research except in the year 2017 however year 2020 is still not completed. Year wise distributions of research papers were shown in the below table 1. The maximum 439 (29.62%) of articles published in the year 2019 followed by 233 (15.72%) of articles were published in 2018 while the minimum 5 (0.34%) of articles were

published in the 2011. The overall year wise distributions of publications were shown in table 1 and in fig no1.

<b>Table No 1: Published articles on cloud computing</b>		
<b>Year</b>	<b>Articles</b>	<b>%</b>
2011	5	0.34
2012	24	1.62
2013	42	2.83
2014	70	4.72
2015	141	9.51
2016	200	13.50
2017	151	10.19
2018	233	15.72
2019	439	29.62
2020	177	11.94
<b>Total</b>	<b>1482</b>	<b>100.00</b>



## 5.2 Highly-cited articles on cloud computing

Table No 2 represents the highly cited article on Cloud Computing. The article published in the year 2013 entitled “Honey bee behavior inspired load balancing of tasks in cloud computing environments” has received 386 citations followed by article entitled “Secure integration of IoT and Cloud Computing” received 376 citations. The least 125 citation received by the article entitled “Automated cropland mapping of continental Africa using Google Earth Engine cloud computing”. One cannot judge the end of citation for an article. As the research grows on, the citations also may go on increasing depending on the productivity of the research findings.

<b>Table No 2: Highly-cited articles on cloud computing</b>				
<b>Sl. No</b>	<b>Authors</b>	<b>Title</b>	<b>Year</b>	<b>Cited by</b>
1	Dhinesh Babu L.D., Venkata Krishna P.	Honey bee behavior inspired load balancing of tasks in cloud computing environments	2013	386

2	Stergiou C., Psannis K.E., Kim B.-G., Gupta B.	Secure integration of IoT and Cloud Computing	2018	376
3	Gangwar H., Date H., Ramaswamy R.	Understanding determinants of cloud computing adoption using an integrated TAM-TOE model	2015	247
4	Misra S.C., Mondal A.	Identification of a company's suitability for the adoption of cloud computing and modelling its corresponding Return on Investment	2011	236
5	Priya N., Sridhar J., Sriram M.	Vehicular cloud computing security issues and solutions	2016	214
6	Priya N., Sridhar J., Sriram M.	Mobile large data storage security in cloud computing environment-a new approach	2016	213
7	Bera S., Misra S., Rodrigues J.J.P.C.	Cloud Computing Applications for Smart Grid: A Survey	2015	208
8	Modi C., Patel D., Borisaniya B., Patel A., Rajarajan M.	A survey on security issues and solutions at different layers of Cloud computing	2013	200
9	Sivaraman K., Kaliyamurthi K.P.	Cloud computing in mobile technology	2016	158
10	Xiong J., Thenkabail P.S., Gumma M.K., Teluguntla P., Poehnelt J., Congalton R.G., Yadav K., Thau D.	Automated cropland mapping of continental Africa using Google Earth Engine cloud computing	2017	125

### 5.3 Prolific authors

The top 10 prolific authors in cloud computing research during the period 2011-2020 depicts in below table 3. The Authors, Chana I, Kumar N and Iyengar were contributed 11 articles each followed by Sangaiah A K contributed 10 articles, Priyadarshinee P and Yuvaraj M contributed 9 each, Pattnaik P K and Raut R D contributed 8 articles each and finally Sood S K and Baranwal G contributed 7 articles each

Table No 3 : Prolific Authors		
Sl. No	Author	Articles
1	Chana, I.	11
2	Kumar, N.	11
3	Iyengar, N.C.S.N.	11
4	Sangaiah, A.K.	10
5	Priyadarshinee, P.	9
6	Yuvaraj, M.	9
7	Pattnaik, P.K.	8
8	Raut, R.D.	8
9	Sood, S.K.	7
10	Baranwal, G.	7

### 5.4 Top Institutions publishing articles on cloud computing

Table No 4 shows the ranking of the affiliated institutes published papers on Cloud Computing. On the basis of analysis it is found that Vellore Institute of Technology, Vellore is published largest number of articles on Cloud computing i.e. 119 followed by K L Deemed to be University with 80 articles, Anna University with 57 articles, Bharath Institute of Higher Education and Research with 51 articles, Sathyabama Institute of Science and Technology with 40 articles, Thapar Institute of Engineering & Technology 34 articles, SASTRA Deemed University 33 articles and remaining are institutes published below 30 articles.

<b>Table No 4: Top Institutes publishing articles on cloud computing</b>		
<b>Sl. No</b>	<b>Institution</b>	<b>Articles</b>
1	Vellore Institute of Technology, Vellore	119
2	K L Deemed to be University	80
3	Anna University	57
4	Bharath Institute of Higher Education and Research	51
5	Sathyabama Institute of Science and Technology	40
6	Thapar Institute of Engineering & Technology	34
7	SASTRA Deemed University	33
8	Vels Institute of Science, Technology & Advanced Studies	29
9	Saveetha School of Engineering	26
10	Saveetha Institute of Medical and Technical Sciences	23

#### *5.5 Top 10 Source Title in Cloud Computing Research*

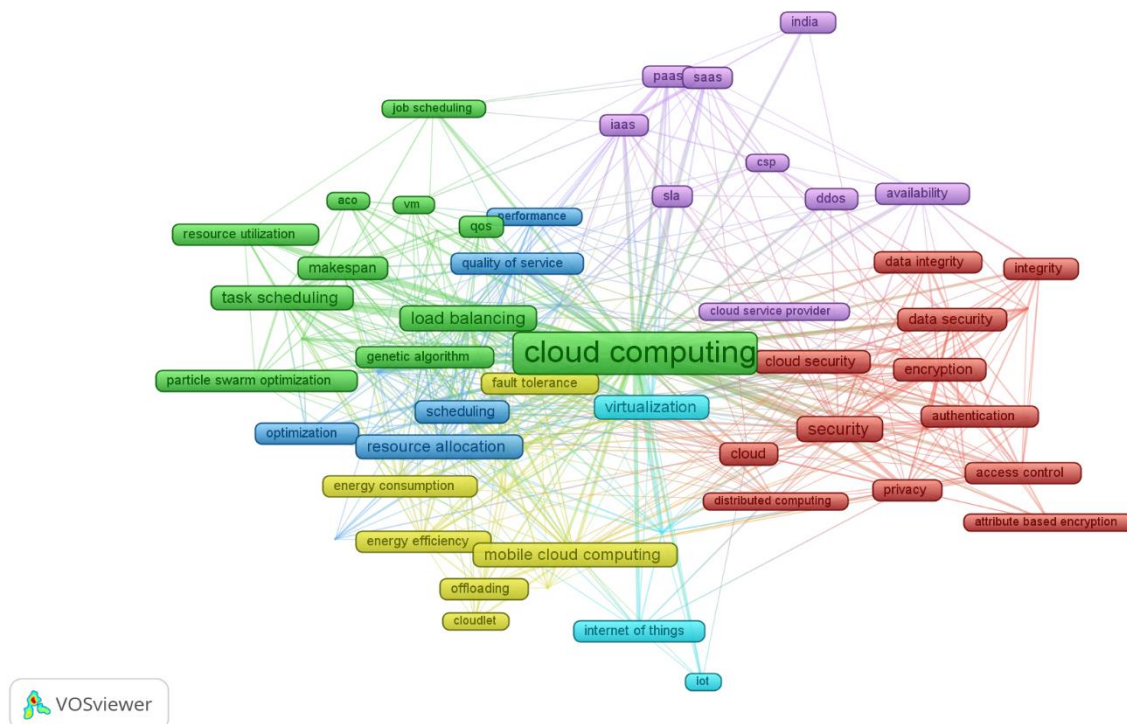
Table No 05 portrays the top 10 sources title which one published the largest number of articles on cloud computing. It is observed that the International Journal of Applied Engineering Research published largest number of articles i.e. 120. Journal of Advanced Research in Dynamical and Control Systems is at second position with 105 Publication followed by International Journal of Innovative Technology and Exploring Engineering with 86 publications. International Journal of Recent Technology and Engineering is in fourth position with 73 articles, International Journal of Engineering and Technology Uae is in fifth place with 50 articles. The source entitles Cluster Computing is in tenth position with 31 articles in the analysis.

<b>Table No 5: Top 10 Source Title in Cloud Computing Research</b>		
<b>Sl. No</b>	<b>Source</b>	<b>Documents</b>
1	International Journal Of Applied Engineering Research	120
2	Journal Of Advanced Research In Dynamical And Control Systems	105
3	International Journal Of Innovative Technology And Exploring Engineering	86
4	International Journal Of Recent Technology And Engineering	73
5	International Journal Of Engineering And Technology Uae	50
6	Indian Journal Of Science And Technology	43
7	International Journal Of Engineering And Advanced Technology	40
8	International Journal Of Scientific And Technology Research	34
9	International Journal Of Pharmacy And Technology	33
10	Cluster Computing	31

#### *5.6 Keywords co-occurrence map of cloud computing articles*







**Figure 3 Co-occurrence map of author keywords/terms**

## 6. CONCLUSION

A total of 1482 articles found published on cloud computing from 2011 to 2020 with increasing trend the highest recorded in 2019 with 439 articles. The articles entitled Honey bee behavior inspired load balancing of tasks in cloud computing environments by Dhinesh Babu L.D., Venkata Krishna P in the year 2013 receiving high citation though there are several articles getting published. Vellore Institute of Technology, Vellore is the top institute with 119 articles. Chana, I., Kumar N, Iyengar are the prolific authors. Number of research on Cloud computing growing worldwide where it seems less in India though having research institutions. Research on cloud computing is mapped on the basis of research literature published and indexed in the databases which are widely using.

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## **8. Acknowledgement**

Authors wished to acknowledge to SCOPUS database and all the studies listed in reference for cumulating the resources for preparing this paper.