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Cloud Computing Technology: A Scientometric Assessment of Global Level Research Output based on the Scopus database

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Abstract

Cloud computing technology is one of the most emerging technologies in the field of Computer Science.The present study aims at analyzing the research output performance of Cloud Computing Technology published in the Scopus database from 2007 to 2019. The various bibliometric components of the 73174 research records are published in the study period. The study shows the various indicators of cloud computing technology literature, such as Year wise growth rate, Relative Growth Rate (RGR), Doubling Time (Dt), country wise, Research Institute wise, Most prolific authors and form-wise, etc. The maximum number of publications were recorded in the year 2018 and further, it is found that RGR is gradually increasing and at the same time doubling time of the literature is gradual decreases over the study period. On an average 5678 articles and 51954 citations are being published and received every year during the study period, the majority of the publications have three and two authored papers and received nine citations per publication during the study period. The highest number of publications were published by Buyya, R .i.e285 articles (H index-72). China (19123-26.13%) has published the highest number of articles in the field of cloud computing technology and most publications are published in the form of conference papers and research articles. Further, the highest degree of collaboration (r=.9)is observed in the field of cloud computing technology and Beijing University of Posts and Telecommunications (1143) has emerged as one of the top research institutes, and Communications in Computer and Information Science journal is the most productive journal in the field of cloud computing technology. Finally, it can be revealed that a lot of research activity is being taking place and promotion of collaborative research culture is also observed in cloud computing technology.

Keywords: Scientometric Analysis, Bibliometric, Authorship Pattern, Collaborative Research, Cloud Computing Technology.

Introduction:

Scontometric is the quantitive study of the disciplines of science-based on published literature and communication. “It identifying an emerging area of scientific research, examining the research over time. or geographical and organizational distributions of research publications” (Glossary of Thompson, 2008). It is one of the most important measures for the assessment of scientific productions. “It involves quantitative studies of scientific activities including among other publications, so overlaps bibliometrics to some extent” (Tague-sutclififfe, 1992, Mogali et al 2011). “Scientific Literature is a reflection of scientific activity and productivity” (Gharfield, 1979). It deals with the quantification of written communication, which helps in the measurement of the published knowledge. It throws light on the pattern of growth literature. Interrelationship among different branches of knowledge productivity, authorship pattern and degree of collaboration, the pattern of collection building, and their use. It helps in formulating need-based collection, building policy, and provides authentic data to inform managers and library professionals to take judicious decisions in the process of document selection. It offers a set of measures for studying the structure and process of scholarly communication (Subramanian 1983). “It is defined as the study and measurement of publication pattern of all forms of written communication and their authorship in a given area of research” (Sengupta-1985). The present study aims to analyze the trend and characteristics of various bibliometric aspects of cloud computing technology research publications.

1. **About Cloud Computing Technology**:

It is a new branch of computer science, “a network of remote servers hosted on the internet to store, manage, and process data than a local server or a personal computer, it is a general term used to store anything that involves delivering hosted service over the internet”(Vahid Delavari-2019). The cloud symbol is used to represent on the internet since 1994. It is a group of networked elements providing computer system resources especially data storage and computing power facility, it is also called a data center

available over the internet. Presently, it is one of the emerging areas in the field of computer science and it is greatly used in corporate and software industries for managing , maintaining and processing their data resources in the cloud environment.

3.Review of Literature

Several studies have been reported on the scientometric subject for the last four decades to evaluate the research output published across the world. Some of the important studies have been reviewed and scaned to make the study more tangible and visiable. The some of the premier works like Subramanian (1983) Kumar Sneha Gupta (1990) &Garrison (1992) have made to assess the contribution of scientific research output through bibliometric techniques. Arunachalam S(2001). Bhattacharya etal (1997) analyzed productivity, literature growth, and subject distributions and their citations. In 1994 Sudhier has conducted study on the contribution of scientific research in Kerala during the study period of 1994-1997 and noticed that the growth rate of scientific research output of Kerala has shoots to 201.67% and corresponding increases of national output.Nagapual (1995) reveals the research productivity of chemistry literature with a sample of 53977 publications from 2000 to 2009. Mahapatra and Padmanav (2006) have envised the growth of scientific research literature on Orissa published during 1985-2004. In the study, the authorship pattern, year wise growth, the subject wise breakup of papers, category of journals, place of origin, length of papers, and productivity of journals were studied. GavisiddappaAnandhalli and DanappaPatar (2015) investigated the research productivity of the Vikalpa journal and studied the various bibliometric components of 437 articles such as year wise growth, Authorship Pattern, Degree of Collaboration, and country-wise and document type. The study reveals that single authors' pattern is most dominant than multiple authorship and India is a major contributor to the Vikalpa journal. Hadagali, Gururaj, and Gavisiddappa Anandhalli(2015) have studied the growth of literature in the field of neurology does not follow the Linear or Logistic model, however, it follows closely the Exponential Growth Model. Finally, the study can be concluded that there has been a consistent trend towards increased growth of literature in the field of neurology literature.

5. Need for the study

An attempt has been made to analyze the research trend and their characteristics in the field of cloud computing technology literature published in the Scopus online database version from 2007 to 2019 by using bibliometric techniques.

6. Objectives of the study

The main objective of the study is to analyze the growth pattern of cloud computing technology literature over the study period, the specific objectives of the study are as follows.

1. To examine the quantification of publication and growth rate of literature over the study period in the field of cloud computing technology.
2. To examine the relative growth rate and doubling time of the publications over the study period.
3. To study the authorship pattern and degree of collaboration of publications.
4. To find out the most prolific authors and most prolific institutions in the field of cloud computing technology.
5. To study the distribution of publications by country wise and institution wise.
6. To identify the form-wise distribution of articles in the field of cloud computing technology.

7. Methodology

The researcher has collected the required research data from the online version of the Scopus database on cloud computing technology from 2007 to 2019 and it is used as the main source of data for the present study. The researcher has used cloud computing technology for searching the recoreds on given field, an overall 73174 records were retrived as a result of search made in the database. The searchers were further limited to document type such as articles from books, journal articles, conference volumes, reviews, case studies. To test the objectives of the study the necessary data has been collected such as year wise, country wise, research institute wise, most prolific authors, form-wise and subject wise, etc. Finally, the given dataset was organized, analyzed, and presented in the form of tables and graphs for interpretation and discussion to draw the meaningfull conclusions.

8. Analysis and Interpretation

The bibliographical data so collected from the online version of the Scopus database on cloud computing technology from 2007 to 2019. As many as more than 73174 publications are considered as the main source of data for the present study. The collected data was entered in an excel sheet and analyzed and tabulated with the help of frequency, percentage, and drawn the meaningful conclusions.

Table-1 Contribution of Research Publication by Year wise

Year	No of records	% of records	No of Citations	%of citations	Cum N	Cum %
Before 2008	20	0.03	244	0.04	244	0.03
2008	97	0.13	7810	1.16	8054	0.16
2009	709	0.97	36873	5.46	44927	1.13
2010	2114	2.89	69581	10.30	114508	4.02
2011	4505	6.16	80058	11.85	194566	10.18
2012	5440	7.43	79757	11.81	274323	17.61
2013	6834	9.34	88125	13.05	362448	26.95
2014	7184	9.82	72119	10.68	434567	36.77
2015	7881	10.77	71398	10.57	505965	47.54
2016	8864	12.11	67138	9.94	573103	59.65
2017	9252	12.64	53529	7.93	626632	72.29
2018	10175	13.91	37112	5.49	663744	86.2
2019	10099	13.80	11668	1.73	675412	100

Total	**73174**	**100.00**	**675412**	**100.00**		
Descriptive statistics						
		Average No of article	**SD**	**r**	**p**	**n**
No of publications		5628.7692	3798.07572	.317	.291	13
No of citations		51954.7692	30128.78605			

No of citations received per publications=$\frac{No\ of\ citations\ recived}{No\ of\ publications} = \frac{675412}{73174}$

= 9.2302

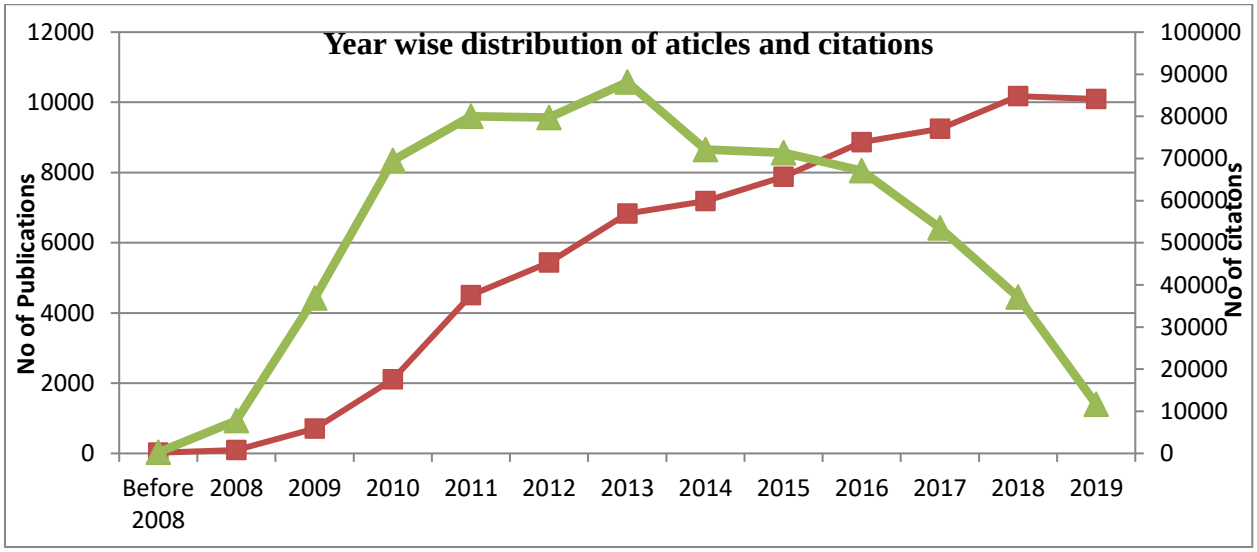

Table-1 reveals the growth of research publications published during the study period from 2007 to 2019 with a sample of 73174 articles published in the field of cloud computing technology. The highest number of articles i.e 10175 was published in the year 2018 which amounts to 13.92% of the total publications and then followed by the second-highest number of articles (10092-13.80%) were contributed in the year 2019. These two year are considered as most productive years. The productivity of the publications in these two years increased to 27.71%. However, the minimum number of articles (20-.003%) were published in the year 2007. Further,

it is observed that On average 5678 articles were published per year during the study period and of 51954 citations were cited during the study period. Furthermore, nine citations per publications were found, and a moderate degree of correlation (r=.37) was observed between the number of articles and the number of citations (r=.37) at 5% of the level of significance. It can be concluded that research activity is gradually increasing over time and there is positive growth of trend in the field of cloud computing technology.

Table-2 Relative growth rate (RGR) and doubling time (Dt) in the field of cloud computing technology

Year	No of records	%	Cum of Records	Log (int)	Log(fin)	RGR	Mean	Dt	Mean
Before 2008	20	0.03	20		2.996	0.000	1. 75	0	0.422
2008	97	0.13	117	2.996	4.762	1.766		0.392314	
2009	709	0.97	826	4.575	6.717	2.142		0.323547	
2010	2114	2.89	2940	6.564	7.986	1.422		0.487236	
2011	4505	6.16	7445	7.656	8.915	1.259		0.550454	
2012	5440	7.43	12885	8.413	9.464	1.051		0.65945	
2013	6834	9.34	19719	8.602	9.889	1.288		0.538126	
2014	7184	9.82	26903	8.830	10.200	1.370	1.7223	0.505718	0.408
2015	7881	10.77	34784	8.880	10.457	1.577		0.439358	
2016	8864	12.11	43648	8.972	10.684	1.712		0.40486	
2017	9252	12.64	52900	9.090	10.876	1.786		0.38793	
2018	10175	13.91	63075	9.133	11.052	1.919		0.361034	
2019	10099	13.80	73174	9.228	11.201	1.973		0.351258	

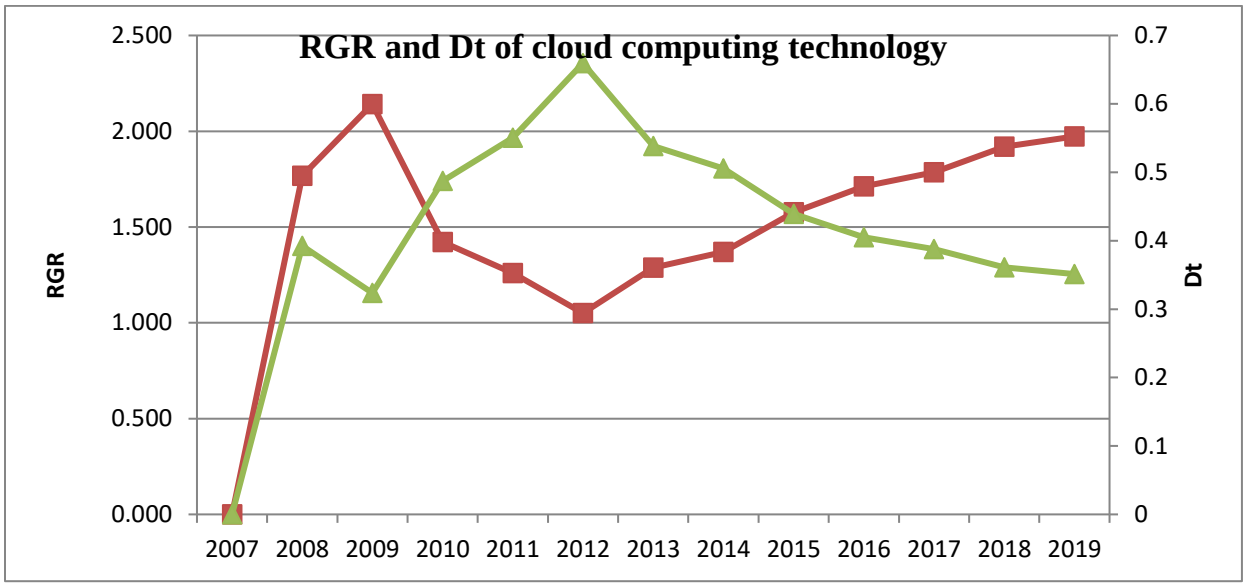

Table-2 clearly shows the mean relative growth rate (RGR) and doubling time (Dt) of the publications in the area of cloud computing technology for the study period. It is noticed that the relative growth rate (RGR) of an article has gradually increased from 1.76 in the year 2008 to 1.973 in the year 2019 for the given study period and the mean relative growth rate was found to be 1.75. at the same time, the doubling time of the publication of articles gradually decreases from 0.392314 in the year 2008 to 0.351258 in the year 2019 and the mean doubling time of the articles was found to be .408 for the given study period. It can be summarized from the above discussion that the relative growth rate of the article is gradually increased and on the other hand doubling time of the articles is gradual decreases.

Table-3 Most Prolific Authors in the Field of Cloud Computing Technology

AUTHOR NAME	No of Publication	No of Citations	h-Index	Rank
Buyya, R.	285	31767	72	1
Jin, H.	143	2301	22	2
Villari, M.	137	1923	23	3
Huh, E.N.	127	1633	19	4
Zomaya, A.Y.	121	3131	30	5

Puliafito, A.	118	1768	21	6
Dustdar, S.	114	2592	29	7
Leymann, F.	110	1353	21	8
Celesti, A.	107	1358	19	9
Ranjan, R.	103	6369	29	10
Total	**1365**	**54195**		

Table -3 shows the contribution of the most prolific authors in the field of cloud computing technology, it is observed that Buyya, R has contributed the highest number of articles i.e 285 articles having an-index of 72 and she has also received 31767 citations for her research work and then followed by the second-highest number of articles i.e 143 are contrived by Jin H. The remaining researchers are also significantly contributed towards the field as shown in the above table-3. It can be concluded that Buyya R and Jin H have emerged as the most prolific researcher in the field of cloud computing technology at the global level.

Table-4 Country-wise Distribution of cloud Computing Technology Publications

Country	**No of Publications**	**%**	**Cum %**
China	19123	26.13	26.13
United States	11919	16.29	42.42
India	10420	14.24	56.66
United Kingdom	3640	4.97	61.63
Germany	3067	4.19	65.82
Australia	2451	3.35	69.17
Italy	2408	3.29	72.46
Canada	2328	3.18	75.65

South Korea	2278	3.11	78.76
Taiwan	2087	2.85	81.61
Others	13453	18.38	100.00
Total	73174	100.00	

Table-4Depicts the geographical wise distribution of publications, out of 73174 articles, China has contributed the highest number of articles which amounts to more than 26% of the total publication then followed by theUnited States of America (16.29%) and India (14.24%), these three countries together contributed more than 56% of the world publications in the field of cloud computing technology. Further, it is observed that United Kingdom (3640), Australia (2451), Italy (2408), Canada (2328), and SouthKorea (2278)are also significantly contributed towards cloud computing technology. However, Taiwan and other countries have made less contribution to the field. So it can be concluded that China, the USA, and India are more emerged countries in the field of cloud computing technology at the global level.

Table-5 Authorship pattern in Cloud Computing Technology

Authorship Pattern	No of Publications	%	No of Authors	No of Citations
No Author	1817	2.483122	0	42
Single Author	5819	7.952278	5819	37719
Two Authors	17703	24.19302	35406	120658
Three Authors	18532	25.32594	55596	164311
Four Authors	13934	19.04228	55736	150960
Five Authors	8051	11.00254	40255	98539
Six Authors	4025	5.500588	24150	50122

Seven Authors	1566	2.140104	10962	21525
Eight Authors	718	0.981223	5744	10377
Nine Authors	318	0.434581	2862	3682
Ten Authors	204	0.278788	2040	3852
Ten+ Authors	487	0.665537	7564	13625
Total	**73174**	100	**246134**	**675412**
Ns	**5819**	**No of Authors**	**246134**	
Nm	**65538**	**No of Papers**	**73174**	

Ns= Number of a single author, Nm=Number of multiple authors

Degree of collaboration (DC) = $\frac{Nm}{Ns+Nm} = \frac{65338}{5819+65338} = .9184$

The average number of Author per paper=$\frac{246134}{73174} = 3.36$

Above table-5 shows, the authorship pattern and degree of collaboration in the area of cloud computing technology, the maximum number of papers are written by three authors (N=18532-25.32594%). The second-highest number of articles are published by two authors (N=17703-24.19302%) and then followed by four authors (N=13934-19.04228%). Five authors respectively. Further, it is observed that single-author paper constitutes more than 7% to the total publications; however, a very negligible contribution is made by six authors or more than six authors. Further, it is observed that there is a high degree of collaboration (r=.9184)is observed. It shows that a lot of collaborative research work is taking place in this area. It is good practice for researchers to share and extended their knowledge inside or outside the organization for the better promotion of collaborative research culture in scientific production.

Table-6 Top ten Research Institutions in the field of Cloud Computing Technology at the global level

Name of the Institute	No of Publications	No of Citations	h-index	Rank
Beijing University of Posts and Telecommunications	1143	8786	43	1
Chinese Academy of Sciences	1079	12360	51	2
Tsinghua University	690	12127	48	3
Ministry of Education in China	658	7316	42	4
Huazhong University of Science and Technology	530	8593	44	5
Xidian University	513	8029	44	6
Vellore Institute of Technology, Vellore	491	2489	23	7
National University of Defense Technology	490	3574	27	8
Beihang University	459	7391	40	9
Shanghai Jiao Tong University	448	6066	38	10
Total	6501	76731		
Total	13002 (17..76%)			

Table -6 gives the account of research publications by the top 10 research institutions at the global level in the area of cloud computing technology all together they published 13002 publications sharing nearly more than 17% of the world publications during the study period. In which, Beijing University of Posts and Telecommunications research institute alone published 1143 articles and then followed by the Chinese Academy of Sciences contributed nearly 1079 articles, Tsinghua University (690), Ministry of Education China (658), Huazhong University of Science and Technology (530) respectively. Indian premier institute Vellore Institute of Technology, Vellore is also published a significant number of (491) articles. It can be concluded that the Beijing University of Posts and Telecommunications emerged as the topmost research institutes in the field of cloud computing technology at the global level

China is the most productivity country in the publication of cloud computing technology, china play very significant role in the field of cloud computing technology research, because it is not only a most productivity country but also top five research institutions/ universities are from China. Hence China is one of the emerging country in the world in the field of cloud computing technology

Top -7 Most Productive Journals in the field of Cloud Computing technology

Journal Title	No of Publications	No of Citations	h-index	Rank
Communications in Computer and Information Science	1148	2794	19	1
Advances in Intelligent Systems and Computing	1019	1968	16	2
Future Generation Computer Systems	702	31792	68	3
IEEE Access	674	8675	42	4
Applied Mechanics and Materials	586	465	7	5
Procedia Computer Science	482	4421	31	6
International Journal Of Applied Engineering Research	408	319	8	7
Cluster Computing	359	2911	27	8
IEEE Transactions on Cloud Computing	353	5411	40	9
Journal of Supercomputing	350	5470	36	10
Total	6081	64226		

Table -7 shows the top ten most productivity journals in the area of cloud computing technology. It found that Communications in Computer and Information Science is on the top of lsit with publication of 1148 publications secured first rank. Accordingly, Advances in Intelligent Systems and Computing occupied second rank with publication of 1019. and Advances in Intelligent Systems and Computing secured third rank. These three journals appears

to be the most productive journals in the field of cloud computing technology. The remaining most productivity journals are also listed in the above table. All the 10 journals are contributed more than 8% to the total world publications during the study period.

Table-8 Type of Document wise distribution

Document Type	No of Publications	%	No of Citations	%
Conference Paper	44692	61.08	63649	30.97
Research Articles	22869	31.25	125607	61.11
Book Chapter	2055	2.81	1701	0.83
Conference Review	1711	2.34	1	0.00
Review	966	1.32	12788	6.22
Editorial	357	0.49	554	0.27
Book	285	0.39	772	0.38
Note	89	0.12	181	0.09
Short Survey	86	0.12	145	0.07
Letter	40	0.05	121	0.06
Erratum	18	0.02	7	0.00

Retracted	5	0.01	10	0.00
Data Paper	1	0.00	0	0.00
Total	73174	100	205536	100.00

It is evident from the table-8 shows the bibliographical form-wise distribution of documents, the large majority of the research output being available in the form of Conference Papers (N=61.08%) and a considerable amount of publications is also published in the form of research articles. A Significant amount of publications were brought in the form of Book Chapter and Conference Review respectively. However, a very few publications is also published in the form of Editorial, Book Note, and Short Survey. It can be concluded from the above discussion that the majority of the publications are published in the form of Conference papers and Research Articles.

9. Major Findings of the Study.

The analysis of the discussion elaborates on the following findings of the study.

1. The present stud has analyzed nearly 73174 publications in the field of cloud computing technology during the study period of 2007 to 2019.
2. The highest number of research publications (N=10175-13.91%) were published in the year 2018 and followed by (N=10099-13.80%) in the year 2019.
3. It is observed that on an average of 5628 articles were published per year during the study period, at the same time3.6 authors per paper were observed and further 9 citations per paper were also received during the study period.
4. The majority of the articles are written by three authors (18352) and two authors (17703) in the field of cloud computing technology.
5. The highest degree of collaboration (r=.918) is observed in the field of cloud computing technology.

6. The relative growth rate has been increased from 1.766 in the year 2008 to 1.973 in the year 2019 and at the same time doubling time of an article has been decreases over some time.
7. The highest number of articles (N= 19123)was contributed by China.
8. Bivvy has made the highest contribution to bypublishing285 research articles.
9. The Majority of the research output is being published in the form of conference papers (44692-61.08%) and research articles (22869-31.35%).
10. Communications in Computer and Information Science and Advances in Intelligent Systems and Computing are the most productivity journals in the field of cloud computing technology.
11. Beijing University of Posts and Telecommunications and the Chinese Academy of Sciences is the most reputed and most productivity research institutions in the field of cloud computing technology at the world level.

10. Conclusion:

This research study was carried out from quantitative prospective to understand pattern of research trend and development in the field of cloud computing technology indexed in the Scopus database from 2007 to 2019 world wide. Biblimetric indicators are used to evaluate the scientific productivity and quantification. As we know that cloud computing technology is one of the emerging and promising areas in the field of computer science. The bibliometric analysis of the publications in the field of cloud computing technology reveals the some of the significant results and trend in the cloud computing technology research. A total of 73187 articles were published in cloud computing technology from 2007 to 2019 at the global level. There is a positive growth trend is observed during the study period. Las two years shows the spectacular grwoht in the publications. It can be analysed from the study that significant research activity is being taking place in the field of cloud computing technology. The study shows a remarkable difference between the number of single authors and multiple authors. The study concludes that multiple authorship research is predominant as compared to single author contributions. China, USA and India are the most productivity country in the worldin the field of cloud computing technology. Beijing University of Posts and Telecommunications (1143) has emerged as one of the top research institutes, and Communications in Computer and Information

Science journal is the most productive journal in the field of cloud computing technology hence the high degree of Collaboration is observed in the field of cloud computing technology. It is good practice to share and extended their knowledge with like-minded people within their organization or outside the organization for the promotion of collaborative research culture.

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